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RADIO WORLD

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The First and Only National Radio Weekly
616th Consecutive Issue—Twelfth Year

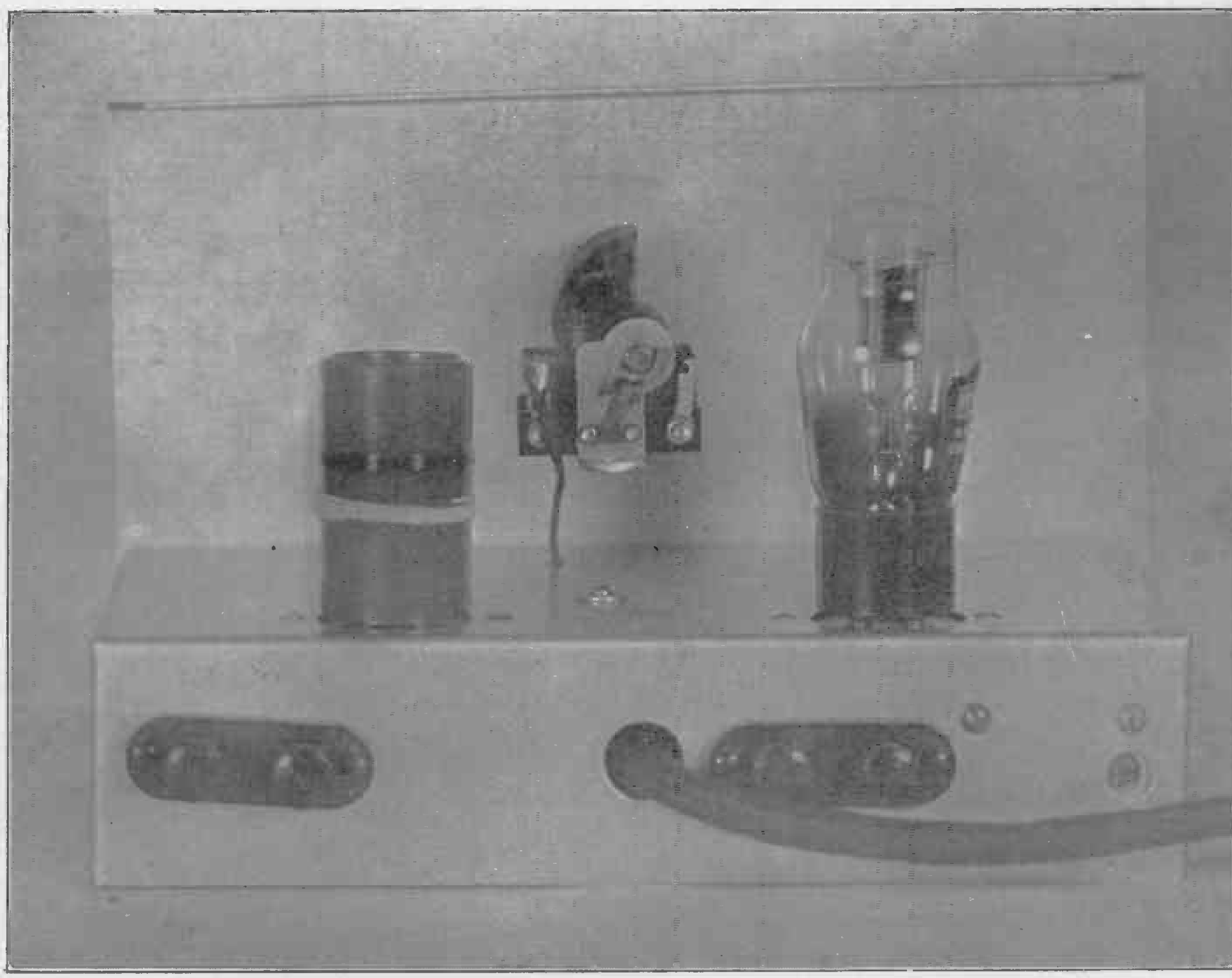
BEST WAY TO USE 2A3 OUTPUT

Permeability Tuning

A Direction Finder

Permeability Tuning Oscillators

SHORT WAVES ON ONE TUBE



For an earphone listening post or for feeding an audio amplifier this one-tube short-wave set may be used. See page 20.

SPECIAL GIFT LIST

Reliable Radio Tips

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4 tubes $1.45

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Four-tube receiver uses 1-57, 1-58, 1-80, and 1-47 pentode; five-tube set uses 1-57, 1-58, 1-80, and 2-47's. Both models use a dynamic speaker especially designed for the output of the pentodes. The receivers are encased in a beautiful hand-rubbed walnut cabinet. Price, 4-tube A. C. receiver **$9.95**

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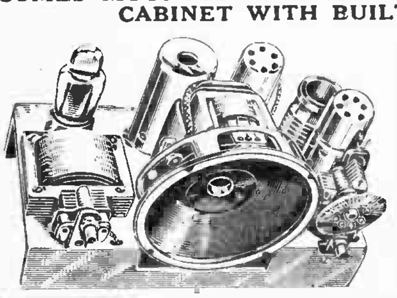
Four Tube A.C. Short Wave Receiver

COMES MOUNTED INTO A BEAUTIFUL MODERNISTIC CABINET WITH BUILT-IN SPEAKER



Looks like a midget broadcast receiver. Will tune in short wave stations from all parts of the world with ease. Uses four coils to cover the short wave bands from 15 to 200 meters. The built-in power supply is entirely free from hum or disturbing line noises. Uses an ultra-sensitive dynamic speaker to aid in tuning in the weaker signals.

Kit of parts...... **$17.50**

Wired and tested........$2.00 extra

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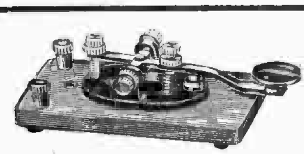

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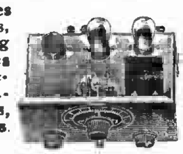

Economical! Uses two 2-230 tubes, which assures long battery life. Tunes from 15-200 meters. Pulls in amateurs, police calls, etc. Kit of parts **$5.50**

Wired..$2.00 extra Tubes.......$1.50

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Powertone Two-Tube Battery Receiver

Enclosed in a handsome crystal finished metal cabinet. Can be built by any one. Beautiful full vision modernistic vernier dial aids in logging weaker stations. Will receive all types of short-wave signals, police, amateur, ship-to-shore, airplane, etc.

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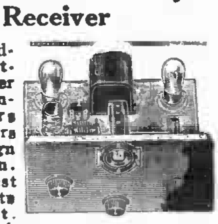

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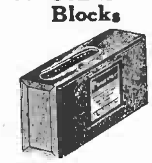

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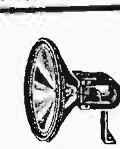

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ROLAND BURKE HENNESSY
Editor

HERMAN BERNARD
Managing Editor

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TWELFTH YEAR

J. E. ANDERSON
Technical Editor

J. MURRAY BARRON
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A DIRECTION FINDER

BATTERY-OPERATED LOOP RECEIVER THAT ALSO REVEALS THE SENSE—USEFUL ON SMALL BOATS PARTICULARLY

By J. E. Anderson

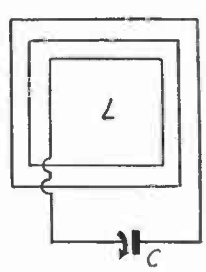


FIG. 1
A loop inductance and a condenser form the essential feature of a radio direction finder.

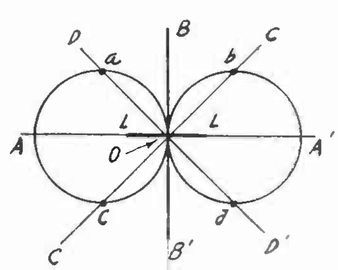


FIG. 2
This diagram shows how a loop receives signals coming from different directions.

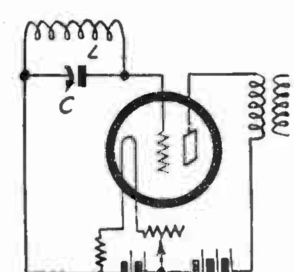


FIG. 3
The loop and condenser are connected to a detector or amplifier to make signals audible.

DIRECTION finding by means of loop antennas is now a well developed art and is used as an aid in navigation both on the sea and in the air. Beacons have been established for ships of both kinds, and both beacons can be used for both air and sea ships. Besides the regular beacons, every broadcast and commercial radio station is a beacon that can be used if its location is known.

All direction finders operate on the principle that a loop antenna will receive signals traveling in the direction of the plane of the loop and that it will not receive signals traveling in the direction at right angles to the plane of the loop. It might be thought at first that the loop is set so that the signals are received loudest, but exactly the opposite is true. When the direction of a beacon is to be determined the loop is turned so that no signal is received because in that manner the most accurate determination is possible.

Principle of Operation

In Fig. 1 we have the essential circuit of a loop antenna. It simply consists of a coil and a tuning condenser, the coil having the form of a large loop. The loop may be square, circular, octagonal, or any other form. It should be comparatively compact as to the turns, yet the turns should not be too close together for that will increase the distributed capacity. Neither should the axial length of the loop be too large for that increases the capacity of the loop to ground.

In Fig. 2 is shown the reception pattern of the loop antenna, where LL represents the loop seen from above. If the signals travel in the direction AA' or in the opposite direction, the current in the loop is maximum and is proportional to the diameter of either circle. If the signal travels in the direction DD', or in the opposite direction, the current in the loop is proportional to the distance 0a or 0d. Likewise, if the signal travels in the direction CC', the current in the loop is proportional to the distance 0b or 0c. If the signal travels along the line BB', which is at right angles to the loop, the current in the loop is zero. It will be noticed that the current changes rapidly from zero to rather large values as the angle changes from the right-angle incidence. It is because of this rapid change that the loop is turned so that LL is at right angles to the direction of the signal. The source of the signal, of course, is first established when the loop is turned so that the signal is strong, and it is identified by the signal characteristic. If the signal comes from a beacon, that signal has a particular sequence of dots and dashes and time intervals. If the station is a broadcaster it is necessary to wait for the station announcement, unless it is identified by the approximate direction and the frequency on which it is operating.

Errors in the Loop

The pattern shown in Fig. 2 is that for a perfect loop. Ordinarily there is an antenna effect in the loop, due to unsymmetrical distribution of capacity. This will have the effect of distorting the double circle, or figure-eight, pattern. For example signals coming from A' might be weaker than those coming from A. When this is the case signals are not zero along the line BB', nor along any other line. They are not even minimum along the line BB', but the line of minimum strength is bent toward C and D'. If the distortion is great enough,

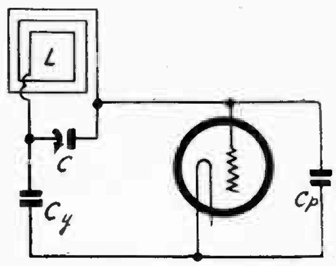


FIG. 4
In this circuit the tuned circuit has been balanced with respect to ground to eliminate direction errors.

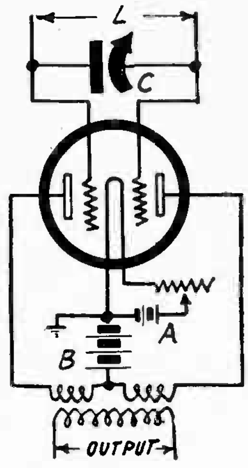


FIG. 5
Here balance is obtained by using a 53 in push-pull.

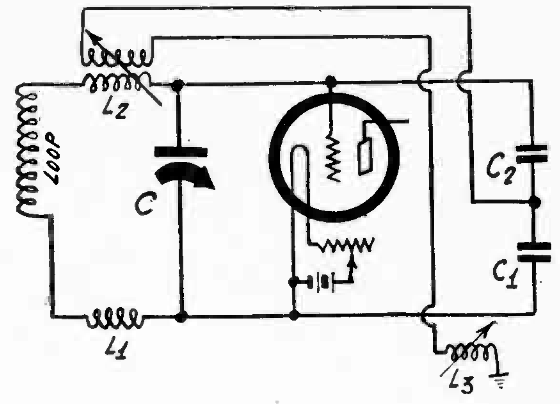


FIG. 6
A sense finder has been inserted in this directional receiver without upsetting the balance.

there will be only one minimum, or zero, and that will be in the direction A'. To avoid this distortion of the pattern, and hence the error in making direction observations, all distributed capacities must be balanced so that the distributed capacity measured from the center point of the loop, on the upper side, is exactly the same in both directions.

The question of unsymmetry enters when the loop is connected to a detector circuit. In Fig. 3 we have a typical circuit such as is used. L is the loop and C the tuning condenser. Now one side of the loop and the condenser is connected to the grid while the other side is connected to the filament circuit. Naturally, the unbalance is very great, for one side of the circuit is virtually grounded while the other is at high potential. There would be no direction from which the signal received is zero with this circuit. One method used to balance the loop with respect to ground is shown in Fig. 4. A small condenser Cg is connected between the side of the condenser that was grounded and the filament and a similar condenser Cp is connected from the grid to the filament. The filament may now be grounded and by adjusting the two balancing condensers it is possible to effect symmetry. When the two balancing condensers have the proper values the midpoint of the loop is at ground potential and so is the midpoint of condenser C. In other words, there is just as much capacity to ground on one side of the tuned circuit as on the other. Now the reception pattern is that shown in Fig. 2.

Detection of Signals

It will be noticed that Cg is in effect the grid stopping condenser, and therefore a high resistance leak can be connected across it to convert the tube into a detector. In order not to upset the symmetry by this resistance, a similar resistance could be connected across Cp, although the internal grid resistance of the tube would serve this purpose. Hence it would be necessary only to adjust the resistance across Cg to be equal to the internal resistance of the grid circuit when signals are practically zero. The arrangement has the disadvantage that the rotor side of the variable condenser is at a high potential. This, of course, does not matter when the circuit is permanently tuned to the beacon stations, but it would be troublesome when the circuit must be tuned to different frequencies.

Using Balanced Detector

In Fig. 5 is shown one way of balancing the loop and tuning condenser by the use of a symmetrical tube. A suitable tube for this purpose is the Wunderlich, which has two grids, one plate and one cathode. Another is the 53, which consists of two equal triodes in one envelope. When Wunderlich tube is used the balance cannot be extended to the plate circuit, but this is of little importance if the tube is used as a full wave detector. If the 53 is used, on the other hand, the balance can be extended to the plate circuit and the two tubes would be used as a push-pull amplifier. Detection could be effected in another tube. Grounding of the filament is possible when the symmetrical tube is used, but grounding of the tuning condenser is still to be desired. By making C in two equal units and connecting these in series it is possible to ground the common rotor and still leave the circuit balanced.

The Sense Finder

By referring to Fig. 2 we note that it is impossible to tell whether the signals come from the direction B or that of B'. Obviously a direction finder that cannot tell the difference between north and south, or east and west, is of little use. There must be some way of telling the difference between the two possible directions of a station. A device which does that is called a sense finder. It consists of a mean for introducing unbalance. Suppose, for example, that the station lies in the direction A. The circuit will give maximum response when the loop is turned as in the figure. Now if unbalance is introduced, the signal will either increase or decrease, because an additional voltage is either added to the signal or subtracted from it. If there is an increase, it is known that the station lies in the direction A; if there is a decrease, it is known that it lies in the direction A'. Hence by turning the loop at right angles to its position in the figure, zero reception will result provided the circuit has been restored to balance. But now it is definitely known that the station is not in the direction A'.

Fig. 6 shows a balanced circuit with a provision for introducing unbalance when required. The balancing is done by condensers C1 and C2 as in the other cases. L3 is a coil in an antenna of the ordinary type. This picks up a signal and part of it is introduced into the tuned circuit by the variable coupler the secondary of which is L2. Since the coil L2 would upset the balance, a coil L1 of equal inductance is put on the opposite side of the circuit.

This arrangement, perhaps, is superior to any of the others for it not only provides a sense finder but it also provides a means of locating the direction of a station without turning the loop to maximum. If L3 and the coupling between L2 and its primary are adjusted so that the voltage introduced into the tuned circuit by way of L2 is exactly equal to that picked up by the loop, the signal will be zero in one direction, A' in Fig. 2, and it will be very large in the opposite direction, A in Fig. 2. In directions B and B' it will be equal to the voltage introduced by either the loop or the antenna. In direction A it will be equal to the sum of these two. Hence if the loop is turned so that no signal is received, it is known definitely that the station lies in that direction. The loop, of course, would be marked so that no ambiguity would result.

Circuit of High Sensitivity

Fig. 7 shows a complete circuit for direction finding. L is the loop, which is tuned by two equal 350 mmfd. condensers, the junction of which is grounded. The two equal 30 tubes are biased by a small battery the voltage of which is chosen for amplification rather than detection. The output of each tube is delivered to another tuned circuit having a 350 mmfd. tuning condenser. The primary of the tuned transformer is tapped at the midpoint so that the first stage is push-pull. Symmetry of

(*Continued on next page*)

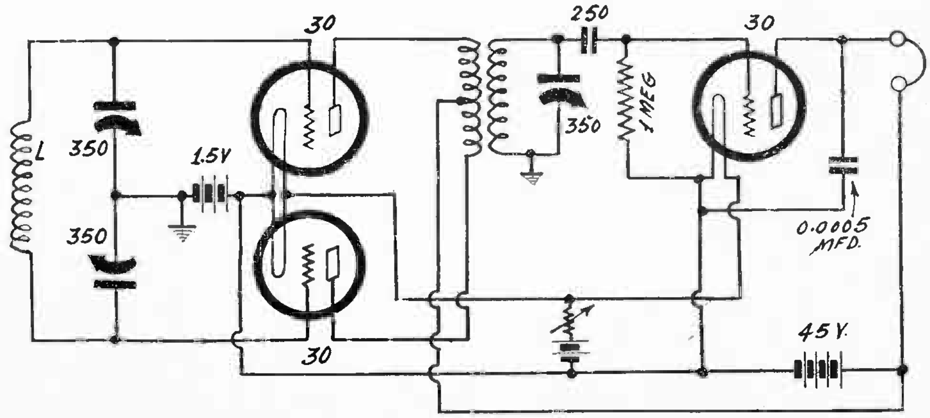


FIG. 7
A complete receiver for direction finding. The tuned circuit is balanced, the amplifier push-pull, and the detector is conventional. A three gang condenser will serve for tuning.

A Compact Direction Finder

(Continued from preceding page)

the loop circuit is obvious, but this is no better than the balance of the two condensers.

The circuit requires a three gang condenser of ordinary type. The inductance of the loop L should be twice as great as the inductance of the secondary of the interstage transformer, because the capacity in the loop circuit is only one-half as large as that in the second tuned circuit. The large loop required is advantageous because the signal picked up is proportional to the cross section area times the number of turns.

The detector used in this circuit is regular in every respect. It has a 250 mmfd. grid condenser, a one megohm grid leak, and a 500 mmfd. by-pass condenser in the plate circuit across the phones. The plate voltage on the detector, as well as on the amplifier tubes is 45 volts. A higher voltage might be used on the amplifiers if there is no limitation on the weight of the batteries. If a higher voltage is used on the plates a correspondingly higher voltage must be used on the grids of the amplifier tubes.

In case a sense finder is to be added to the circuit in Fig. 7, a good way of doing it would be to put on a small winding on the second coil and put the antenna current through that winding. By adjusting the voltage introduced into the second tuned circuit in this way to equality with that introduced into the circuit from the first stage, there would be one direction, and only one, from which no signals could be received. A line at right angles to the loop would then point in the direction of the station when no signal could be heard.

Balancing the output of the push-pull amplifier is not so vital as balancing the input circuit, but the tracking of the three tuning condensers is of first importance, not only to maintain the balance of the input circuit to the first stage but also to keep the sensitivity high. If the condensers are well made the rate of change of capacity should be the same in all of them. This would only leave distributed capacities to upset the tracking. Now there will be a considerably higher minimum capacity in the loop circuit than in the interstage circuit. Hence more of the trimmer on the third condenser will have to be used. It is more important, of course, that the two condensers in the loop circuit track than that the third condenser track with these, for lack of tracking of the third condenser would only change the sensitivity whereas lack of tracking of the other two would upset the balance

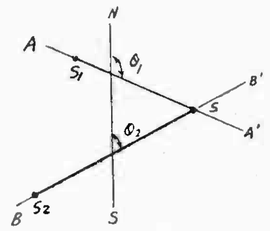


FIG. 8

If the ship S has a transmitter its location can be determined by finding its bearings by directional receivers at two other stations S1 and S2 by the method of triangulation.

and would introduce errors in the directions found.

The tubes used are 30s because they require very little power for their operation. The filament current will only be 180 milliamperes for the three tubes and the plate current will not exceed about 10 milliamperes.

When a ship at sea desires to know its exact location and the weather is unfavorable for making astrononmic observations it often uses radio as a means, provided that it is equipped with a radio transmitter, and all ships of any size are so equipped. The ship's operator sends out a signal indicating that he wants his location. Two or more stations on shore, say S1 and S2, pick up the message and get ready with their direction finders. The ship's operator continues to send a signal while the two land operators get the directions from which the signal comes. One may get a direction Θ_1 as the bearing and the other Θ_2. One of the operators on land sends his observation to the other, or both send their observations to a third, which may be the ship's operator. When one person has received the two bearings he plots them on a map. He knows the location of each station and the bearing of the ship at that station. He then draws a straight line through the station on the map with the proper bearing. The line for station S1 may be AA' and that for the other BB'. It is then known that the ship is at the intersection S of the two lines. When this location has been deterrmined it is transmitted to the captain of the ship. This process only takes a few minutes for the land operators are always on watch and ready with their equipment.

There is a considerable error in this method, but it is less than the error would be with any other method available when no star or land mark can be seen. Sometimes a third station takes part in the location of the ship, and then the accuracy is greater, for then there will be three possible intersections of the three lines and the ship will most likely be in the center of the little triangle thus formed. Of course, if the three lines all converge on one point, it is quite certain that the ship is at that point.

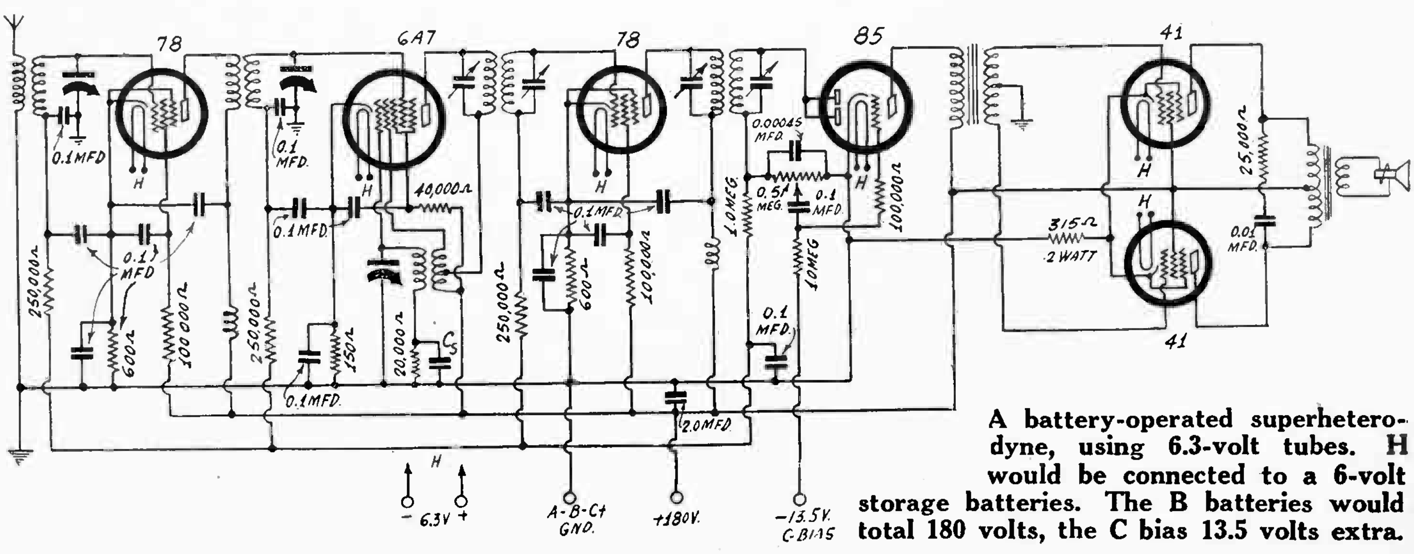
Sometimes other ships at sea take part in the observations, for two other ships may be in clear weather and they would know their exact locations. Thus they could send the bearings of the ship in thick weather and help to locate it.

It should be noticed that no sense finder is required when the method of triangulation is used, for two lines will only intersect at one point although they may be extended indefinitely in either direction.

All civilized countries have established radio beacons for the aid of ships at sea, and all have broadcast stations which can also be used. Thus any sailor who has a direction finding receiver on board can find his way wherever he may be on the ocean. Many small, as well as large ones, have navigated long distances with no other aid than a loop receiver.

When a loop antenna is used on a steel ship it is necessary to make correction for the distortion of the wave front by the hull of the vessel. When the signals come from directly forward or aft no correction is necessary provided the loop is in the middle of the ship measured along the beam, for then the distortion is symmetrical with respect to the loop. Likewise, when the signals hit the ship broadside from either direction no correction is necessary, provided that the loop location is approximately amidship. When the signals come from any other direction the distortion may be quite large, necessitating subtracting or adding as much as 10 degrees from the observed bearings. In any case the direction finder must be calibrated on the ship to get most accurate results.

This correction is not limited to the radio direction finder, but applies equally well to the magnetic compass. The earth's magnetic field is also disturbed by the steel mass of the ship. The field is disturbed least when the ship is at right angles to it or when it is parallel with it.

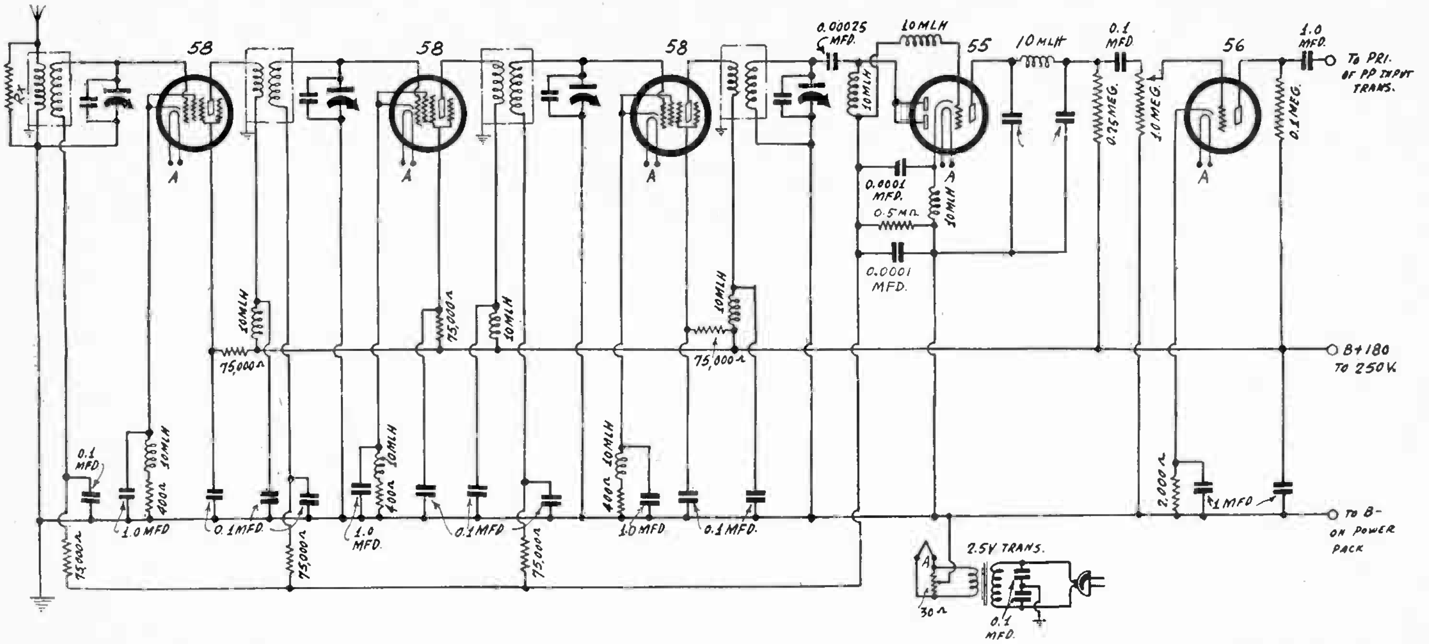


A battery-operated superheterodyne, using 6.3-volt tubes. H would be connected to a 6-volt storage batteries. The B batteries would total 180 volts, the C bias 13.5 volts extra.

A T-R-F TUNER

TO FEED A PUSH-PULL POWER AMPLIFIER; THREE R-F STAGES HAVE AUTOMATIC VOLUME CONTROL

By Jack Tully



A tuned-radio-frequency tuner, with heater transformer but without B supply. This circuit will feed a power amplifier consisting of push-pull input transformer, output tubes (triodes or pentodes) and B supply

WHERE no very severe selectivity requirements are imposed by one's location, a five-tube quality tuner may be constructed on the tuned-radio-frequency plan, on the basis of the accompanying diagram. There is enough amplification to drive push-pull triodes, so that the output of the 56 may be connected to the primary of a push-pull transformer in a power amplifier, which power source also must supply the B voltage. Usually there is provision in the power amplifier for heating the tubes in the tuner, but if not the heater transformer may be included as shown in the diagram.

Since a 55 is used as half-wave diode detector, the preferable method for t-r-f models because the full rectified voltage is thus obtained, special coupling must be provided due to the grounded rotor of the tuning condenser ahead of the detector. No grounding is directly possible at the input to the diode, so a stopping condenser and high-inductance choke are used. The condenser may be 0.00025 mfd., and the choke should have as high an inductance as practical, no less than 10 millihenries.

Effect of Choke on Secondary

The inclusion of a choke of 10 millihenries, assuming the choke were directly parallel with the tuned winding, would reduce the inductance of the secondary by about 10 millihenries, but due to the condenser the reduction will be less, as coupling is not unity. However, there is a reduction, and compensation may be introduced by winding three or four more turns on the secondary that faces the choke. This avoids selectivity reduction due to poor tracking at the higher frequencies, considering the fourth tuned circuit. If the choke is as high as 250 millihenries no special compensation would be necessary, but chokes of such high inductance must be of low distributed capacity.

Since there are four tuned stages, of which three are r-f amplifiers, there is always present the possibility of squealing, particularly at the higher frequencies. Filtration has been introduced in plate, screen and cathode legs to meet this condition, but in addition it may be necessary to put a resistance in parallel with the primary of the antenna coupler. This resistance is marked Rx on the diagram.

Automatic Volume Control

Its value cannot be specifically stated for all circuits, as the greater the oscillation tendency, the lower the resistance should be. In an extreme instance Rx may have to be 2,000 ohms, but values around 5,000 ohms may be expected to suffice. In any event the resistance should be no lower than actually required. Any type resistor, any wattage, may be used.

This resistor does not spoil the selectivity or the sensitivity, in fact, since there can be no enjoyable reception when there is squealing, the resistor is a "gainer" instead of a "loser," and besides when the circuit is operated just below the regenerative state it is most sensitive, whereas oscillation practically destroys the audibility sensitivity.

Automatic volume control has been introduced in the three r-f stages, as the audio gain is sufficient to compensate for the drain on sensitivity this introduced. As can be seen, there are two stages of audio in the tuner itself, the first in the triode of the 55 and the second in the 56. Hence the push-pull output tubes in the power amplifier are the third audio stage. That is why there is plenty to spare for a.v.c. purposes.

Plate and Screen Voltages

The B voltage feed is not critical, and may be between 250 and 180 volts. The 75,000-ohm screen resistors assume 250 volts, but if considerably less B voltage is fed to the tuner these resistors may be smaller, say, 50,000 ohms, otherwise had better remain as stated. If for any reason it is desired to reduce the screen voltage on any tube, as for instance if it oscillates (as the first one might), this may be accomplished quite readily by putting a resistor between that screen and ground, somewhere about the same value as the series screen resistor used. The voltage on the screen otherwise would be around 90 volts, with 75,000-ohm series resistors, main feed 250 volts.

Orthodox screen voltages do not have to be used, but any screen voltage that yields quiet and satisfactory performance, between 50 and 100 volts.

If the cathodes are filtered the bypass condenser across the series network of r-f choke and biasing resistor should be large, say, 1.0 mfd. This is because of the d-c resistance of the choke being in series with the d-c resistance of the biasing resistor, and the further fact that all currents (plate, screen and suppressor) unite in the cathode leg.

The filament transformer, if used, may have a center tap. If so, use that. If not, include the low-resistance potentiometer shown across the secondary of this transformer, ground the arm, and adjust for minimum hum.

Coil Information

Conventional coils may be used, provided they do not have oversized primaries. Coils with non-inductively related plate chokes, and capacity coupling to the secondary by a turn or two of wire, one end of this winding free, other end to plate, are satisfactory, as are coils with not more than 20 turns primary wound over the secondary. If you are winding your own coils you may put 20-turn primaries over 127-turn secondaries. No. 32 enamel wire on 1-inch diameter, shields 2 1/16 inches outside diameter, a ½-inches high, aluminum or copper, not iron or tin. Use 131 turns for the last secondary if the choke is 10 millihenries.

The bypass condensers in the plate circuit of the 55 are of 0.0001 mfd. capacity (100 mmfd.), and the rest of the values are imprinted on the diagram.

PENTAGRID TUBES

In Amplitude-Stabilized Test Oscillators

ONE MODEL, FOR STRICTLY A-C USE, HAS THE 2A7 TUBE, THE OTHER, OF THE UNIVERSAL TYPE (A-C., D-C. OR BATTERIES) CALLS FOR THE 1A6 VALVE

By Herman Bernard

ELECTRON-COUPLED A-C TYPE OF STABILIZED INSTRUMENT

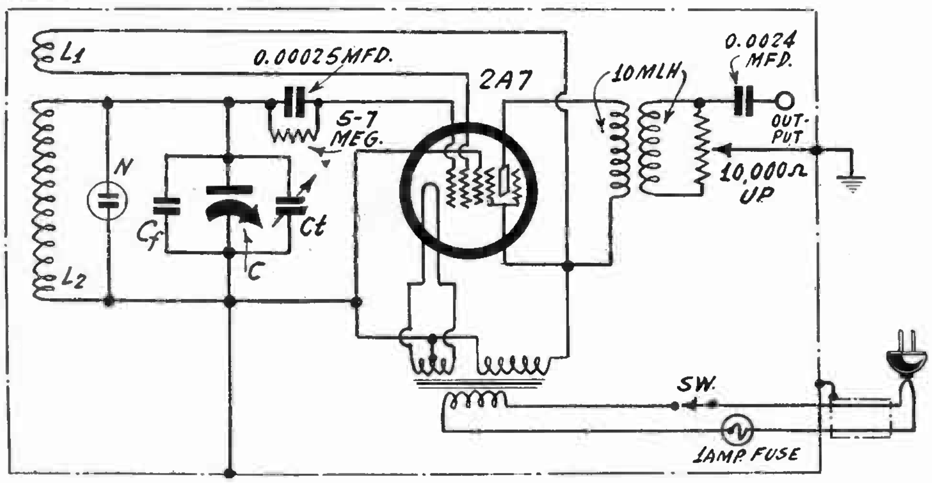


FIG. 1

A strictly a-c model test oscillator, using the pentagrid converter tube for its electron coupling. The triode is the oscillator, control grid of the quadrobe is grounded, and the output is taken through a transformer with primary in the plate circuit of the quadrode. Modulation is constantly present due to the a-c hum, heard at resonance with the tested circuit. Zero beats are always obtainable.

LIST OF PARTS

Coils

One oscillation transformer, secondary (L2) 5 millihenries inductance, primary (L1) 1 millihenry inductance. Coupling between windings loose enough to avoid overheating of the neon lamp (N).
One small power transformer: 110-volt primary, 2.5-volt center-tapped secondary; 110-volt secondary not center-tapped.
One output transformer, consisting of two 10 millihenry r-f chokes closely coupled.

Condensers

One 0.00035 mfd. tuning condenser (C) with trimmer (Ct) built in.
One fixed condenser (Cf), so that it plus Ct equal about 100 mmfd.
One 0.00025 mfd. mica grid condenser (paper condenser unsatisfactory)
One 0.0024 mfd. fixed mica condenser (smaller capacity may be used)

Resistors

One potentiometer, 10,000 ohms up, with a-c switch attached
One 5 to 7 meg. grid leak

Other Requirements

One metal box, 5x5x3 inches
One insulated front panel to fit
One copper foil sheet, size of panel
Four self-tapping corner screws for box
One shielded a-c cable, and plug
One 1-ampere fuse and holder
One neon lamp, 110-volt type, with candelabra base (may be used as pilot lamp for transparent dial)
One dial and escutcheon
Two knobs
One 7-hole socket, medium size
One 2A7 tube
Two binding posts, one conductive for ground, other insulated for output.
Shielded output lead and shielded ground lead.

THE amplitude stability of a grid current type oscillator, and possibly of all oscillators, is considerably improved by use of a high minimum capacity, around 100 mmfd. This can be checked very readily, without expensive instruments, by using a small neon tube of the 110-volt type as indicator. There will be enough oscillation voltage to make the tube glow. If the fixed parallel condenser Cf is omitted, the glow will grow dimmer as the higher frequencies are tuned in, and finally the tube may go out, although the circuit continues to oscillate at a voltage less than the striking voltage of the lamp.

The condenser setting where this instability sets in may be noted if the condenser is calibrated in capacity, and the minimum established by Cf at that indicated. Or, with the steadiness of the flow made familiar by observation at low frequency settings, the condenser may be turned to minimum, and Cf added, of such capacity as to establish the steady glow.

Frequency Ratio

By this method of having a large minimum capacity of course the frequency ratio of tuning is reduced, for it is the square root of the capacity ratio. If the minimum is 25 mmfd. in the circuit, and the actual maximum 400 mmfd., the capacity ratio is 8 and the frequency ratio is 2.83, whereas if 100 mmfd. are added the extremes are 125 and 500, a capacity ratio of 4, or frequency ratio of 2. For a harmonic type oscillator, as this is, a frequency ratio of 2 is satisfactory.

The amplitude stability becomes of a high order, but this does not necessarily mean frequency stability. However, there can be no frequency stability if there is amplitude instability, and to make the frequency stability good the leak may be relied on for stabilizing at the lower frequencies thus resulting, and the coupling to load is by the electron method, with a fairly constant impedance attenuator.

Leads Shielded

In the a-c model, using the 2A7 tube, the triode is used as the oscillator, as usual, while the control grid of the quadrode is grounded, but the plate voltage applied to the quadrode causes the attraction of electrons moving at the frequency of the oscillating circuit, and a.c. is thus reincarnated in the output transformer, which consists of two tightly-coupled high-inductance chokes.

The modulation is constant, consisting of the a-c hum. The use of a transformer with two secondaries, one for heater, the other for plate voltage equal to the line voltage (1 to 1 ratio) enables grounding of the high-voltage without danger. Thus the oscillator circuit and one side of the high voltage are grounded to the metal shield box, which is itself grounded.

All leads, including connecting wire for external ground, a-c cable, and output, must be shielded and shield grounded, otherwise the attenuator will have small effect.

Nothing has been said about frequencies to be covered, but they will depend on what service is intended. If one desires to have the fundamental range 100 to 200 kc, assuming 500 mmfd. maximum, due to 100 mmfd. added, and to circuit capacities, where the condenser itself is rated at or about 0.00035 mfd., the inductance would have to be 5 millihenries. Naturally, this would be a honeycomb coil, and the number of turns ordinarily would be around 700. The tickler would have about half that number of turns, or fewer, and placed far enough away from the secondary so that the oscillation does not cause the neon lamp to glow with great brightness or get unduly hot.

Inductance Selection

When the oscillator is calibrated for the fundamental, which may be done by striking heats with broadcasting stations, harmonics may be used for multiples of the fundamental, and the multiplication done mentally from the scale data.

The secondary inductance has to be selected on the basis of the maximum capacity and the lowest frequency, and then the minor adjustment for the high-frequency and is made by means of the usual trimmer across the variable condenser. In the diagram, Fig. 1, C is the tuning condenser, Cf is the fixed capacity, and Ct is the trimmer. Depending on the value of Ct, which is usually around 35 mmfd. at maximum, Cf may be less than 100 mmfd. by about that amount.

The Universal Model

In the universal model, meaning that the oscillator works on 90-120 volts a.c., d.c. or batteries, the 1A6 tube is used, and external ground is connected only to the metal box and to the slider of the attenuator or volume control.

It is important to observe this precaution against grounding the oscillator circuit directly, otherwise a short of the line may result. To complete the metal surrounding, since the panel will be bakelite or other insulator, a backing of copper foil is cemented to the panel, and oversized holes drilled to pass condenser frame and output post, but a conductive contact with the foil established at one of the corners of the metal box where a screw is to be inserted. The box should have inside corner brackets, and if these are painted or otherwise treated, scrape off the surface and apply some solder. Then the friction contact will be sufficient.

Leak and Condenser

The 1A6 diagram shows the proper way to drop the line voltage for filament supply, so that the difference voltage will be between plate and negative filament, including also the drop in the filament. The filament potential designations apply only to the socket or tube connections, and not to the polarity of the voltage, as this is alternating when a.c. is used, although on d.c., from line or batteries, the polarities are significant of application voltages.

The same values of grid leak and condenser are used, also the same value of stopping condenser in the output. The real reason for the high leak is to insure modulation by grid blocking when d.c. is used in line or battery form, hence 5 to 7 meg. should be used for the universal model, although smaller grid condenser and smaller resistor may be used on the a-c model, Fig. 1. The stopping condenser, 0.0024 mmfd,. is rather large, to insure sufficient coupling at intermediate frequencies, but if the coupling proves ample, it is well to use a smaller capacity here, in either model, in fact as small as gives satisfactory intermediate-frequency coupling.

The same coil is used in both models, the same attenuator, 10,000 ohms up, without limit, and the same test of steadiness of amplitude is applied by use of the neon lamp (N), as previously outlined.

UNIVERSAL MODEL, FOR 90-120 V, A-C OR D-C LINE OR B BATTERIES

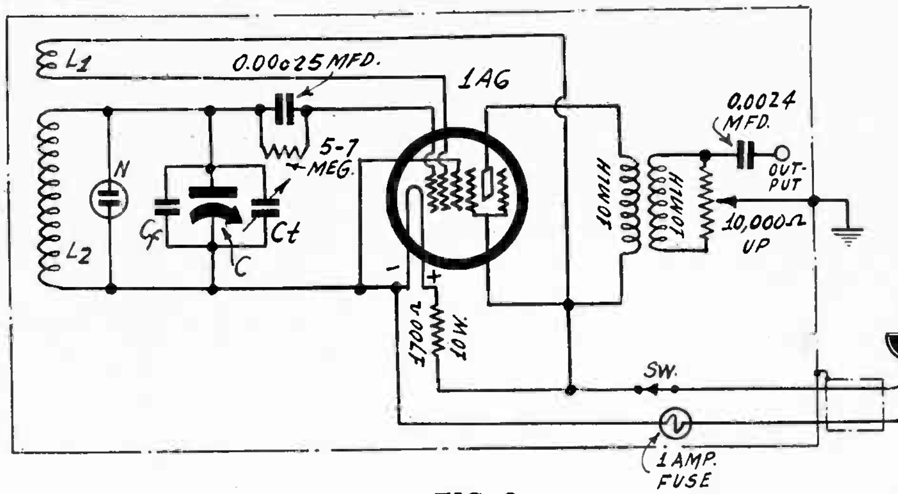


FIG. 2

A universal model test oscillator, using a 1A6 tube. Whether a.c. or d.c. is used from the line, 90 to 120 volts, the same service prevails. While on a.c. the hum is stronger as modulation, nevertheless there is grid-blocking modulation as well, as this must be included so there will be modulation on d-c uses (line or B batteries). Care must be exercised not to connect the oscillator circuit proper to the grounded metal box in this model.

LIST OF PARTS

Coils

One oscillation transformer, secondary (L2) 5 millihenries inductance, primary (L1) 1 millihenry inductance. Coupling between windings loose enough to avoid overheating of the neon lamp (N).
One output transformer, consisting of two 10-millihenry r-f chokes closely coupled.

Condensers

One 0.00035 mfd. tuning condenser (C) with trimmer (Ct) built in.
One fixed condenser (Cf), so that it plus Ct equal about 100 mmfd.
One 0.00025 mfd. mica grid condenser (paper condensers unsatisfactory)
One 0.0024 mfd. mica fixed condenser (smaller capacity may be used)

Resistors

One potentiometer, 10,000 ohms up, with a-c switch attached
One 5 to 7-meg. grid leak
One 1,700-ohm, 10-watt resistor

Other Requirements

One metal box, 5x5x3 inches
One insulated front panel to fit
One copper foil sheet, size of panel
Four selftapping corner screws for box
One shielded a-c cable and plug
One 1-ampere fuse and holder
One neon lamp, 110-volt type, with candelabra base (may be used as pilot lamy for transparent dial scale).
One dial and escutcheon
Two knobs
One 6-hole socket
One 1A6 tube
Two binding posts, one conductive for ground, other insulated for output
Shielded output lead and shielded ground lead

Four Cathode Ray Tubes, Rectifier and Sweep Oscillator Announced

RCA Radiotron Co., Inc., announced four cathode-ray oscillograph tubes, the 903, 904, 905 and 906, also a high-voltage half-wave rectifier, the 878, and a gas triode, the 885. The rectifier supplies the necessary high voltage for the oscillograph tubes and the gas triode is a saw-tooth-wave sweep oscillator.

The following are data on the cathode-ray tubes:

The 903 has a 9-inch diameter fluorescent viewing screen, designed for use with magnetic deflection control, and has an indirectly-heated cathode. Maximum voltage, 7,000 volts. Six-hole socket required.

The 904 has a 5-inch fluorescent viewing screen and permits both electrostatic and electromagnetic deflection control. Maximum voltage, 4,600 volts. Six-hole socket required.

The 905 has a 5-inch diameter screen with two sets of plates for deflection control. Maximum voltage, 2000 volts. Five-hole socket required.

The 906 has a 3-inch screen, with two sets of plates for deflection. Maximum voltage, 1,000 volts. Medium seven-hole socket required.

The indirect heater takes 2.5 volts on all the cathode-ray tubes.

As for the rectifier 878, the maximum a-c plate voltage is 7,100 volts at maximum 5 ma continuous. Filament 2.5 volts a-c., at 5 amps. Four-hole socket required.

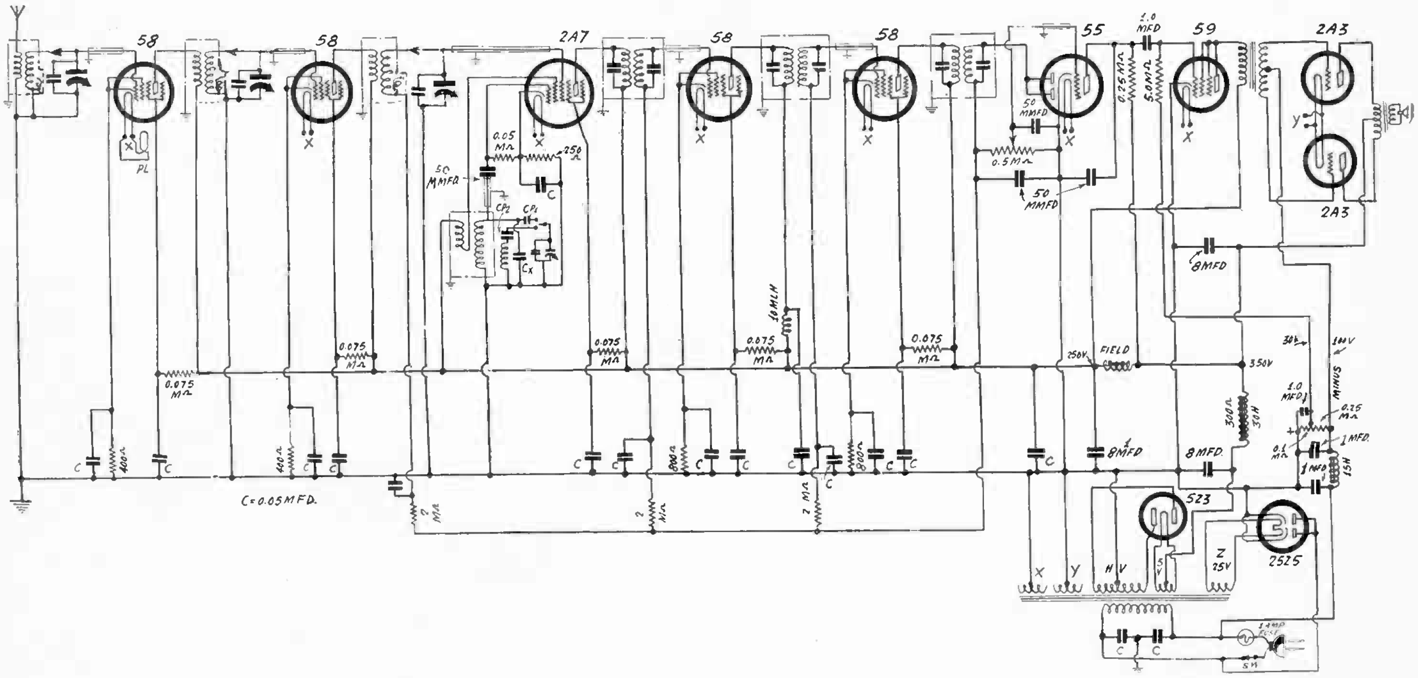
The 885 triode, 2.5-volt heater, 200 to 300 volts maximum, is intended for developing a-c voltages at oscillation frequencies for causing a beam to move horizontally Another would be required if perpendicular sweeping is to be additional, as in television scanning, where the horizontal frequency may be 120 (lines) and the perpendicular frequency (frames) 24. A five-hole socket is required.

A REALLY BIG SET

On a Very Small-Sized Chassis

25 WATTS OBTAINABLE FROM DUAL-RANGE SUPERHETERODYNE BUILT ON CHASSIS 13¼ x 8½ x 3½ INCHES

By Homer A. Wendell



A powerful circuit so arranged that the parts can be fitted on a small chassis, to enable placement in consoles that do not have room for physically larger sets. Yet by Class B operation the output may be 25 watts or more, or by Class A it may be 15 watts or so. The receiver covers broadcast and police bands but coils can be added for the higher frequencies, so that reception to about 12 meters is heard.

AN 11-tube a-c receiver can be built on a chassis measuring only 13¼x8½x3½ inches. The diagram of the circuit is shown, also that of the principal dimensions and holes for the chassis. The circuit is similar to one discussed last week, when, however, much more radio-frequency filtration and some other filtration were included, because there was supposed to be ample chassis room. This time the coupling between primaries and secondaries of coils has been reduced so that the extra radio-frequency filtration, for which there is no room, would not be needed.

Since the circuit is a high-powered superheterodyne, for broadcast reception, it is possible by including a switch and either a secondary tap or extra winding to cover the police-signal bands, as well. Last week the tapped-secondary method was shown. Now a separate winding for this band is used not only in the oscillator but also in the radio-frequency coils. The only reason for this is that the physical construction of the receiver is such that the condenser stator is better left permanently at grid cap, instead of being switched from full coil to the tap.

Connections to Tuning Condenser

If the tuning condenser is imagined in its usual position at right angles to the chassis front, then the trimming condensers are at top, and a shielded lead connects them to the overhead grids of the two r-f tubes and the modulator.

Underneath the condenser are extra lugs for the sections, and from these the leads may be brought to the switch index, and the coil system may be placed underneath the chassis, in fact, right below the three tubes they concern (for the fourth "tube is part of the third tube, on account of use of the 2A7 pentagrid converter).

How to Wind the Coils

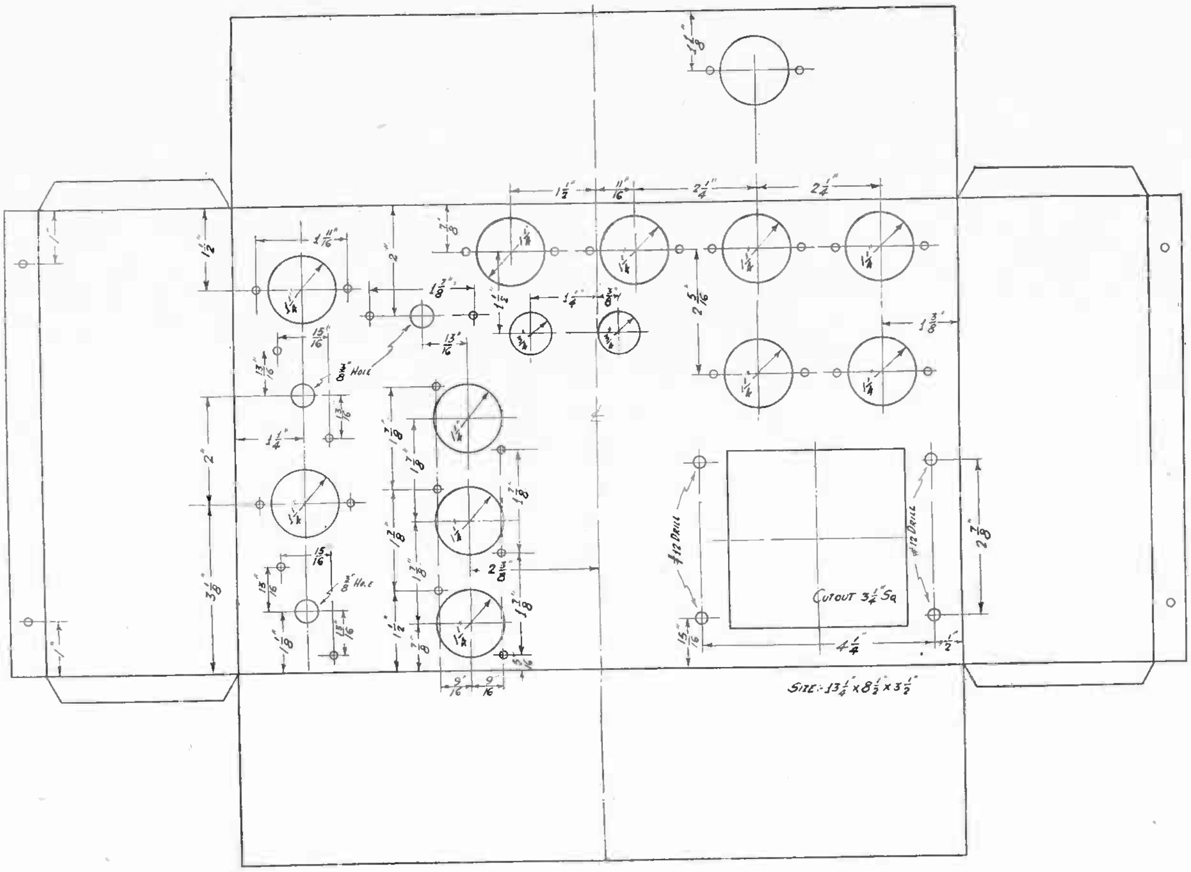
The type of construction suggested is that embodying a single copper shield, about 2.5x 5x3 inches, in which are spot-welded or soldered partitions, separating the four coils. This type of construction is perfectly feasible, and since it is compact and close to the circuits the coils feed, it is to be wondered why the method has not been commercialized.

The coils may be wound on ¾-inch diameter tubing, 160 turns of No. 32 enamel for the r-f secondaries, primaries wound over secondaries, with insulation between, consisting of 15 turns of any fine insulated wire. The oscillator coil, also for the broadcast band, would consist of a 110 turns of No. 32 enamel wire on the same size diameter, the tickler wound over the secondary, consisting of 18 turns. Assuming 42 mmfd. for the r-f circuits (total minima), the highest frequency reached would be 1,700 kc, whereas the oscillator would require 50 mmfd., or 8 mmfd. extra, hence the additional capacity Cx is inserted as a permanent parallel one across the broadcast oscillator, so that for the police bands the minima for all four circuits would be equal.

This equality requires that the inductances be proportioned differently than at the r-f level. For 1,700 kc as a starter at the r-f level (20 microhenries) the extra secondary, wound next to the other secondary, would consist of 32 turns of No. 30 enamel wire, and the oscillator winding would be same as the r-f police winding, since at the high-frrequency end, 5,372 kc, the intermediate frequency is only 8.7 per cent. of the signal frequency. This slight difference can be taken up by oscillator trimmer adjustment.

Frequency Coverage

Since the police band has an oscillator with a slightly greater tuning ratio (3.16 compared to 3.15 for the broadcast band), the 5,000 kc frequency is exceeded, and one may use the standard transmission of the Bureau of Standards on Tuesday evenings 10 to 12 p.m., EST, when this frequency is emitted from WWV, Beltsville, Md. This could be used for the high-frequency trimmer adjustment of the oscillator alone, as



Chassis layout for a 25-watt receiver in a small space. The central blank space, forward, is for the tuning condenser. To the left are three holes in a row for the two r-f and mixer sockets, back to front, in that order. At lower left corner, chassis top, goes the first intermediate transformer, behind that the first i-f tube, second i-f transformer next, and second i-f tube at left rear. To right of that tube, third i-f transformer, and next, at rear, hole for the 55 second detector. Just in front the two smaller holes are for the 8 mfd. electrolytic condensers. The rest of the tubes at rear are, left to right, 59, 2A3 and 2A3. The 5Z3 rectifier goes at right behind the power transformer cutout, and the 25Z5 rectifier to left of the other rectifier.

the r-f trimmer adjustment for the broadcast band has to be retained for the police band.

In other words, the oscillator is adjusted backwards, first the trimmer for 5,000 kc. For the broadcast band, since this trimmer remains in service as already established, the extra capacity, estimated at 8 mmfd., is added, and left across the larger secondary.

Padding condensers are required for both bands. For broadcast frequencies the computed capacity, Cp1, is 508.4 mmfd., while for the police band the computed capacity, Cp2. is 756 mmfd. Due to variations in trimmer settings the computed values are not always satisfactory in practice, but the actual values will be close to those stated, for the inductances wound as directed.

Would Tune Too High

The virtual equality of the capacities (omitting padding henceforth), and the room provided to the right of the tuning condenser's center under the chassis, allow for coils for covering higher frequencies. With a ratio of 3.16, starting at 5,000 kc, the next band would bring you to 15,800 kc and the next band to from 15,000 to 46,400 kc, a region in which there would be little response, because the higher frequencies are too high for this type of construction (around 6 meters).

Less Than Full Condenser

The method of getting around the crowding at the high frequencies, for the fourth or last coil, or even for the third coil, would be to select the inductance for use of less than the full condenser capacity, say, 250 mmfd. for the third coil, and 100 mmfd. for the last coil. The dial would not be turned to higher capacities in these instances. Thus the frequency ratios would be, for the third coil, 2.74 and for the last coil 1.843. The frequency ranges under this system then would be 5,000 to 13,700 kc, and 13,000 to 24,959 kc, or to around 12 meters, a more likely stopping place, as some results can be expected around highest frequency. It is a fact, however, that for the smallest coil the sensitivity drop will be large, compared to all other coils.

25 Watts Output

It is not the present intention to go beyond the broadcast band, but to ascertain the inductance for any band, take the capacity ratio and divide it into the previous greater inductance (for the lower frequency band). Thus since 20 microhenries are used for the police band, the capacity ratio being 7.5 for the next band, the third coil under the special system just detailed would require an inductance of 2.66 microhenries, and the last coil, capacity ratio here 3.4, an inductance of 0.8 microhenry.

The circuit has the same C supply as outlined last week, and the bias may be somewhat more than 100 volts for class B operation (25 watts) or between 50 and 60 volts for Class A (15 watts). This is possible simply by bias adjustment and without any other changes in the circuit, although for Class A operation, the speaker field may carry the power tubes' plate current, and the 30-henry choke be omitted.

SET'S LEAK-CONDENSER-DETECTOR SERVES AS A FREQUENCY DOUBLER

When one wants to build an oscillator and calibrate it against broadcasting stations he may do so readily if he finds one position on each coil that represents a known oscillator frequency. Since harmonics would be used, the problem is to ascertain which harmoiic is which. If the plug-in type coils are used with specified capacities the coil manufacturer's frequency-range statement may be accepted for a low-frequency determination on one coil. If it is possible to build two oscillators, one as frequency-doubler, with a station as frequency standard, the work really may be expedited. However, all sets with grid-leak-condenser detection, including t-r-f sets, and supers with such detection in modulator or demodulator or both, are frequency doublers and their harmonics beat with fundamentals, as well as with harmonics, of the test oscillator to be calibrated. Police signals are a good reference for frequency-determination and besides are frequently heard at night, though not so active during the day.

HOW TO USE 2A3'S T
PUSH-PULL CIRCUIT FA
150-MA FUSE IN COM

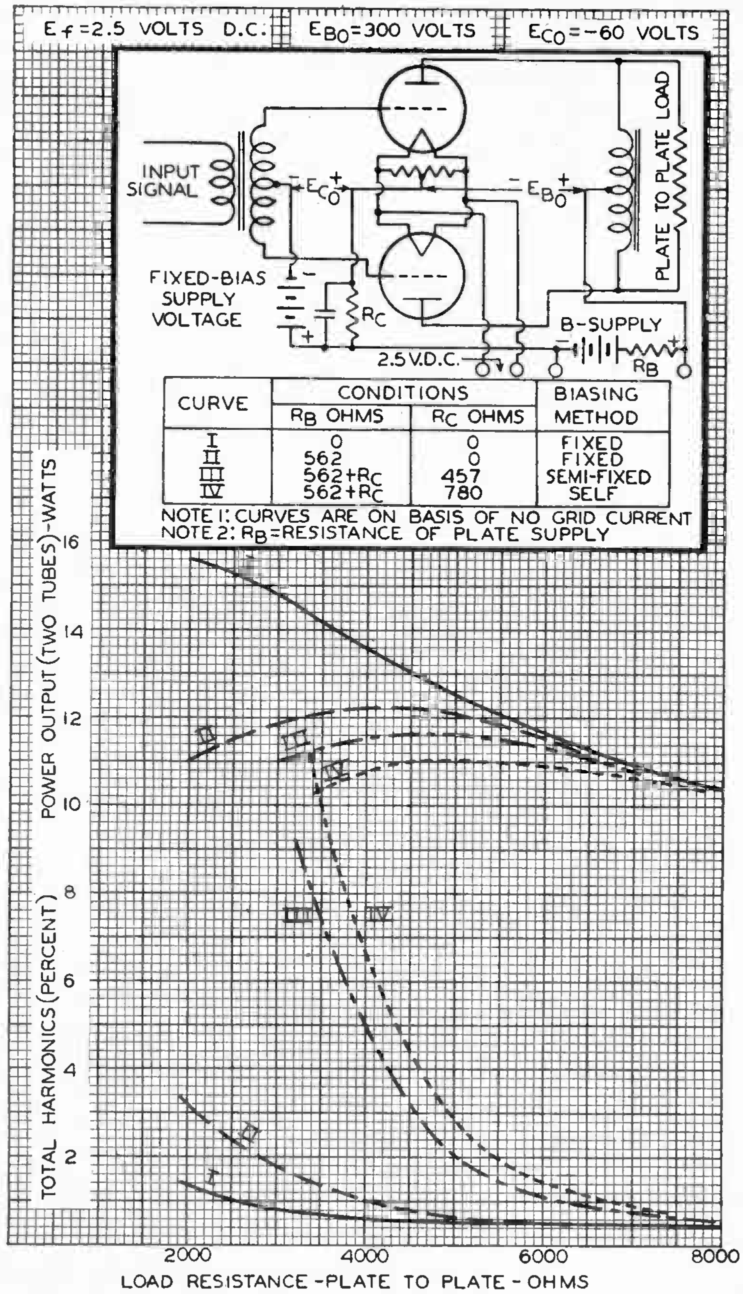


Fig. 1, top left, shows a 56 driving a 2A3 push-pull output, at 60.2 volts negative bias for d.c. on F1 and F2. If a.c. is used the bias should be 62 volts, i. e., L2 slightly higher than 430 ohms d-c resistance. Fig. 2, lower left, shows a 26 used as C bias supply rectifier, when a fuse of 150 ma rating is included.

THE introduction of the 2A3 made possible the design of audio-frequency output systems of unusual power-handling ability and exceptional tone quality. The unique design features incorporated in the 2A3 make possible very high power output at relatively low plate voltages.

In determining the performance obtainable from two 2A3's in Class A push-pull and in selecting output transformer constants, a graphical method of solution can be used. For a general consideration of the method for determining the performance of push-pull audio amplifiers by graphical means, see the paper entitled "Graphical Determination of Performance of Push-Pull Audio Amplifiers" by B. J. Thompson of our Research and Development Laboratory, say RCA Radiotron Co., Inc., and E. T. Cunningham, Inc. This paper appeared in "Proceedings" of the Institute of Radio Engineers for April, 1933.

Strictly speaking, no type of output tube has absolutely linear characteristics. Consequently, a small amount of rectification of the signal voltage usually occurs. The non-linearity of characteristics is therefore responsible for the distortion produced by the tube.

When two tubes are operated in a Class A push-pull circuit, the non-linear sections of their characteristics are made to complement each other to give a substantially linear overall characteristic. This method produces an output free from second harmonic distortion. For this reason it is possible to use a higher bias voltage for push-pull operation than is usually employed for single-tube operation. An increased bias voltage lowers the internal dissipation of the tube and permits the use of higher plate voltages. Higher plate voltages, in turn, make possible higher power output.

40 Ma Current Limit

In order to obtain the higher power output of which the 2A3 is capable, two of these tubes are operated in push-pull under bias-voltage conditions which cause considerable rectification in each tube. Additional plate current, then, is drawn because of rectification, but this increased plate current is useful in obtaining higher power outputs. Under normal recommended operating conditions in a push-pull amplifier, where a plate-supply voltage of very good regulation and a fixed-bias supply voltage are used, the plate current is not cut off during any fraction of the cycle. Consequently, even though the recommended operating conditions specify over-bias grid voltage, this system may be operated as a strictly Class A amplifier.

2A3's should not be operated with more than 300 volts on the plate. The grid-bias voltage should be minus 62 volts when operated from an a-c filament supply and minus 60 volts when operated from a d-c supply. The corresponding static plate current for an average 2A3 is 40 milliamperes. This voltage and current rating for no signal input should not be exceeded for best results.

Fixed Bias and Over-Bias

Fig. 2 shows a circuit arrangement for the 2A3 in which the bias voltage is obtained from a small triode used as a rectifier. This triode must be a type whose cathode comes to an operating temperature quickly in order that bias will be available to prevent abnormal plate current in the 2A3's. Either a type 26 or 01-A is suitable for use as the bias rectifier.

With the circuit of Fig. 1, changes in the d-c plate current of the 2A3 produce some change in bias. With the circuit of

'O BEST ADVANTAGE /ORED WITH FIXED BIAS; MON B RETURN LEAD

Fig. 2, the bias voltage is substantially independent of the plate current of the 2A3's.

The ideal case of fixed-bias operation with a fixed plate-voltage supply gives results as shown by the curves marked (I) in Fig. 3. The curves (II) show the performance with fixed bias but with a plate-supply source having an equivalent internal resistance of 562 ohms. This represents the condition for the circuit of Fig. 2 when a 5Z3 with suitable transformer is used. The performance with an 83 type is intermediate between the values of curves I and II of Fig. 3.

The plate circuits of the 2A3's should be fused in the center-tap lead of the output transformer. This is especially important when fixed bias is used. Should the bias-voltage rectifier tube be removed or damaged, the bias on the 2A3's becomes zero. In that event, unless a fuse is provided for protection, excessive plate current can flow and damage the receiver. A suitable fuse is one similar to the small glass-enclosed type often used to fuse the power-supply line in radio sets and rated at 150 milliamperes.

Self-Bias and Over-Bias Voltage

When 2A3's are operated in a push-pull circuit and are self-biased, a rise in d-c plate current with increasing signal voltages increases the voltage drop across the self-biasing resistor and raises the bias on the tubes. Thus, the operating point on the plate family of the characteristic curves is shifted downward. This shift tends to increase distortion and to lower the power output. Under these conditions, operation intermediate to Class A and Class B is usually obtained at full output since the plate current is cut off for an appreciable fraction of the operating cycle.

When self-biasing circuits are used for the 2A3, it is necessary, therefore, to employ a higher value of plate-load resistance than is used with a fixed or semi-fixed bias arrangement. The purpose of this high resistance is to lessen plate-current swings, limit distortion, and prevent plate-current cut-off at negative signal swings.

Performance of a 2A3 amplifier for self-bias operation (self-bias resistance of 780 ohms) and an assumed internal resistance of the plate-voltage supply of 562 ohms is shown as Curve IV in Fig. 3. A comparison with Curve I, which represents the ideal case of fixed supply voltages, shows the necessity of using a high plate load, as previously stated, in order to obtain high power output and low distortion. Increasing the internal resistance of the plate-voltage supply to the somewhat higher values often used commercially will not materially change results from the values of Curve IV.

Steady Bias Approved

The circuit diagram in Fig. 3 shows the equivalent voltage-supply circuit for the plate and grid-voltage supply. The plate and bias voltages on the power tube at zero-input signal are 300 and minus 60 volts, respectively. (For a-c filament supply, grid-bias voltage is minus 62 volts.)

Curves I to IV show the performance of the amplifier for four combinations of the internal resistance values of the plate-voltage and grid-voltage supply. The plate- and grid-supply voltages are adjusted to values given above. These curves show that it is desirable to use a bias arrangement which will not give bias-voltage fluctuations when the d-c plate current changes. Semi-fixed and fixed-bias arrangements allow higher power output levels to be maintained with a high degree of fidelity.

CIRCUIT WITH SEMI-FIXED BIAS

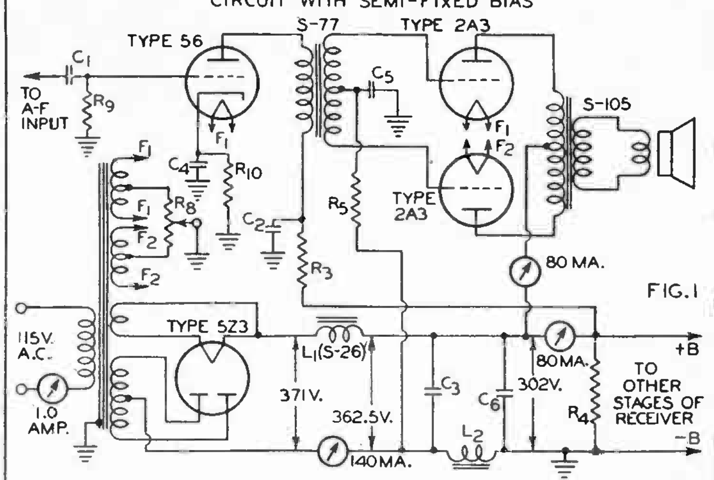


FIG. 1

CIRCUIT WITH FIXED BIAS

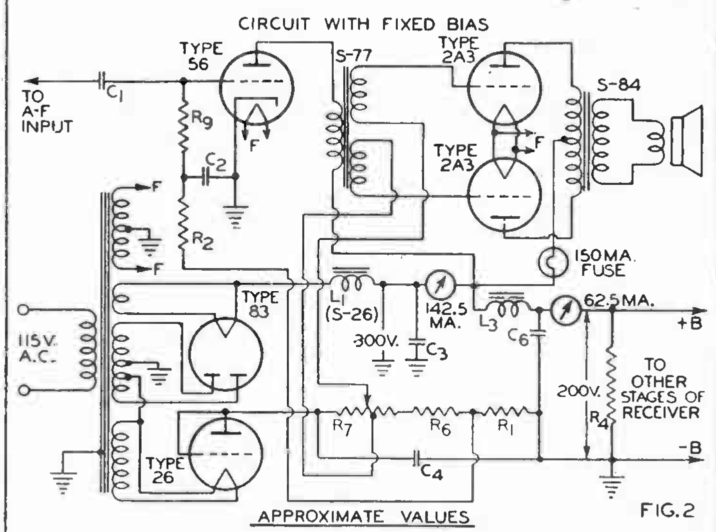


FIG. 2

APPROXIMATE VALUES

C_1 = BLOCKING CONDENSER-0.01 µf
C_2 = BY-PASS CONDENSER-0.25 µf
C_3 = FILTER CONDENSER-10 µf
C_4 = BY-PASS CONDENSER-5 µf
C_5 = BY-PASS CONDENSER-0.05 µf
C_6 = FILTER CONDENSER-5 µf
L_1 = FILTER CHOKE-10 HENRIES AT MAX. MA., 60 OHMS
L_2 = SPEAKER FIELD-430 OHMS
L_3 = SPEAKER FIELD-1600 OHMS
R_1 = 5000 OHMS
R_2 = 200000 OHMS
R_3 = 10000 OHMS
R_4 = BLEEDER
R_5 = 50000 OHMS
R_6 = 22000 OHMS
R_7 = CENTER-TAPPED POTENTIOMETER-2500 OHMS
R_8 = POTENTIOMETER-100 OHMS
R_9 = 0.5 TO 1.0 MEGOHM
R_{10} = 2700 OHMS

The operating characteristics are shown in Fig. 3, with conditions stated and curves given below.

Balancing of 2A3 Circuits

It may be advisable to provide some means for balancing the plate currents of the 2A3 tubes, as this has the effect of balancing out hum voltages present in the plate-supply voltage.

Two methods of accomplishing this are shown in the circuit diagrams. In Fig. 1, a small potentiometer (R_8) is connected between the center taps of the filament windings to permit an adjustment of bias voltage.

Both the circuits of Fig. 1 and Fig. 2

(*Continued on page 22*)

PERMEABILITY TUNING

COMPRESSED IRON DUST CORE OF PLUNGER TYPE AFFORDS WIDE FREQUENCY RANGE

By Einar Andrews

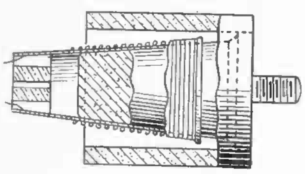


FIG. 1
This shows the construction of an iron dust core radio frequency coil, the inductance of which is varied by permeability.

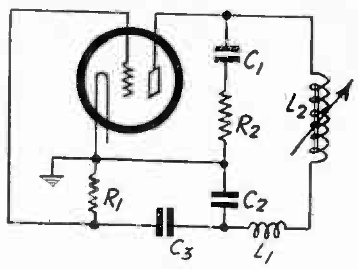


FIG. 2
A Colpitts oscillator in which the tuning inductance is varied by permeability changes. The circuit is shown padded to track with an r-f system.

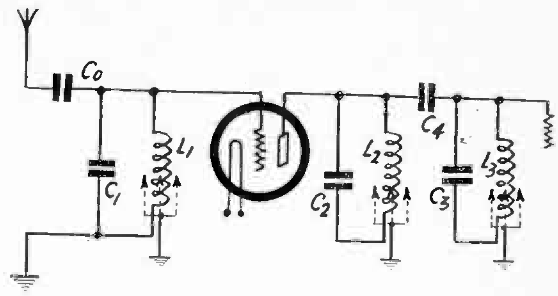


FIG. 3
An example of three permeability-tuned circuits in a radio-frequency amplifier. C0 is small and C1 is adjusted on the basis of the reflected antenna capacity included, though C1, C2 and C3 need not be exactly equal.

TUNING by varying the inductance in a circuit is not new, for it was used long before broadcasting began, and one of the early forms of tuning in broadcast reception employed a means for varying the inductance. We all recall the variometer. Now, this device is usually thought of in connection with squeals and broad tuning, for it was used in regenerative receivers. It cannot be said that it was a good device judging by present standards of reception. Yet it appears that radio is turning back to inductance tuning. No, the old variometer is not coming back. If inductance tuning is to return it must be in a form that is an improvement over anything that we have at present. It appears as if circuits in the future will be tuned by iron, and tuning will be done by varying the permeability of the core of the radio frequency coil.

Let us tell what permeability is. If we have a long solenoid and send a direct current through the winding, there is a certain magnetic flux around the coil, particularly inside it. If a magnetic needle is placed near it, the needle will be deflected. There is a certain magnetic flux "flowing" through the solenoid and the compass needle will line itself up with this flow. Now suppose we put an iron rod through the solenoid. The flux will increase, possibly a thousand fold. Iron conducts magnetic flux better than other ordinary metals or non-metals, just as silver conducts electric electric current better than, say, a rod of bakelite. The permeability is the ratio of the magnetic flux that "flowed" through the solenoid when the iron is in the coil to that which "flowed" before the iron was inserted, the current remaining constant. Only that space which is occupied by the iron should be considered.

Tuning by Means of Iron

Suppose we have a coil which forms a part of an oscillator. A certain frequency is generated by the circuit, which, let us say, is near the upper limit of audibility so that the oscillation can be detected easily. Now let us bring up a piece of iron to the coil. The frequency generated will become lower. If the iron is a rod and it is inserted into the coil the frequency may become very low. Obviously, the iron affects the property of the coil, that is, its inductance, for it is not the capacity that changes by any amount that could account for the large change in the frequency. One definition for inductance is that it is the total magnetic flux associated with a circuit when unit current is flowing. It is clear, therefore, that if the iron increases the flux, the current remaining constant, the inductance of the coil increases.

The increase in the inductance due to the iron may range from a factor slightly greater than unity to a factor as high as 2,000, for good magnetic iron, and even many times higher than that for certain iron-nickel alloys. The amount by which the inductance increases depends on the material and on its disposition with respect to the coil. It is clear that if the frequency of an oscillator can be changed by means of iron or other magnetic substances, that the same thing can be done for a tuner. That is, the frequency of resonance can be changed by varying the amount of iron in the coil or by varying its disposition in respect to the turns.

Iron Losses

But there are losses in iron when used as magnetic cores. Some of these losses are due to hysteresis and some to eddy currents. Hysteresis is due to the fact that it takes work to magnetize the iron. In some steels used for permanent magnets this is very great. In soft iron and alloys used for transformers, the work required to magnetize is very small. The smaller it is, the better is the material for transformer cores. Eddy current losses are due to the fact that iron is a conductor and that current will flow in the core. A good core material should have the highest possible electrical resistance and the lowest possible magnetic resistance, or reluctance.

These losses increase rapidly as the frequency goes up. The hysteresis losses increase because the higher the frequency the more frequently will the work of magnetization and demagnetization then have to be done, and there is the same loss each time. Eddy current losses increase with frequency because the higher the frequency the higher the induced voltages causing the currents. The increase in the eddy current losses is about proportional to the square of the frequency. Hysteresis losses do not increase indefinitely, for at radio frequencies they are negligible.

Another factor that affects the losses due to eddy currents is the length of the paths in which the induced currents can flow. The shorter the paths the lower the loss. It is for this reason that transformer cores are laminated. The laminae are placed in the field so that there is no obstruction to the magnetic flux, but so that there is peak obstruction to the flow of induced currents in the core. To make the paths short the laminae are made as thin as practical, and at the same time insulation is placed between them. Sometimes this insulation may simply be the oxide that forms on the surface of the metal, but sometimes actual insulating layers are placed between.

Stranded Cores

Another way of reducing the eddy current losses is to use stranded cores, that is, cores made of magnetic wire bundled together and insulated from each other. If these wires could be made to meet end to end, this would not greatly increase the reluctance of the magnetic circuit, yet eddy currents would be prevented, but it is obviously impracticable to make a core of thousands of fine wire and have each come around and meet itself. In practice the wires are bundled up through the coil and then brought back on the outside so that the ends overlap and lie side by side. Audio frequency transformers have been made this way. But these do not provide any means for varying the permeability of the core. In shell type transformers an airgrip is inserted for the purpose of preventing saturation. By shortening and lengthening the gap it would be possible to vary the inductance of the coil. A practical scheme for doing this could be worked out if there were any occasion for it.

Dust Cores

In an endeavor to reduce eddy current losses at the high frequencies and at the same time maintain a reasonably high effective permeability, engineers have experimented with iron dust cores. Pure iron, as a rule, is made into an extremely fine dust, then mixed with an insulating varnish and a binder, and finally compressed under terrific pressure. The resulting compact looks like iron, for it is about 95 per cent. iron, and it is reasonably strong. It can be machined into any desired shape. But since the mass is moulded, the usual thing is to put the mixture in forms having the desired shapes so that no machining is needed. In other words, the dust cores are moulded, under high pressure, just as bakelite is moulded. Indeed, the binder often is bakelite.

The smaller the iron particles the lower will the losses due to eddy currents be, but the lower will also be the permeability. High compression is necessary to maintain a high permeability, and also very thin films of binder and insulating materials. When the size of the grain has been reduced to where the losses at broadcast frequencies are low enough to make selective coils, the permeability is not high enough, being of the order of 5 when the grain has a diameter of 0.000001 meter. This is not enough if the permeability method of tuning is to be used because the permeability must then be greater than the square of the frequency band to be covered. By increasing the size of the particles a little, and also the compression, it is possible to increase the permeability to as high as 20, and that is high enough for broadcast frequency tuning purposes. Indeed, a range of permeability change in the coil of only 7.5 is required.

Tuning by Permeability

When tuning is to be done by varying the permeability of the space around the coil, this is first designed as an air core inductance to be correct at the higher frequency end without the aid of the dust core. A fixed condenser is used for tuning this coil to the high frequency, that is, it is fixed after the first adjustment has been made. When lower frequencies are to be tuned in, the iron dust core is brought nearer the coil and that increases the inductance so that the circuit will resonate to lower frequencies.

In practice, the coil is made slightly conical. An iron dust plug, also conical, is moved into the coil along the axis. At the same time, and part of the same chunk of dust compact, an external sleeve is brought up. Then the inductance of the coil is to be greatest, the turns are practically surrounded by the dust core. Of course, there are different methods of construction. In Fig. 1 is shown the cross section of a coil of this kind. It appears that the inner and outer parts of the core were designed so that core moves in on the coil from the right. If it were arranged so that the outer part moved in from one direction and the inner part from the opposite, a closer fit would be possible. A greater variation in the permeability of the space about the coil could be effected that way when necessary.

Mechanical Arrangement

When tuning a gang of circuits by this method, the cores are mounted rigidly on a frame and the coils are moved in respect to them. To cover the entire broadcast band, a stroke less than half an inch is necessary. Therefore a coil and its mechanism for varying the inductance do not take much room. But a stroke of less than half an inch means that the dial readings will be crowded. This can be avoided, however, by using a lever to multiply the movement. For example, a movement of 3/8-inch at the short end could be made into 3 inches at the long end if the long arm, which would be the pointer, is eight times longer than the short arm.

The mechanism used is of the same type as that used for varying the capacity in the "plunger" condensers. That is, the core is a stator and the coil itself is the rotor, and the rotor plunges in and out of the core.

Advantages of Permeability Tuning

Does permeability tuning have any advantages not possessed by capacity tuning? Yes, the main advantage is that the selectivity remains constant throughout the tuning band, and also that the gain is nearly constant for all the frequencies covered by the tuner. Just why is the selectivity constant throughout the band? The reason given is that the inductance increases at the same rate as the resistance of the circuit. That is, if L is the inductance and R the resistance of the coil, L/R remains a constant. This is the damping coefficient of the coil, not the usual selectivity.

The gain of an amplifier using a tuning coil of this type is constant for the same reason. If the circuit is of the tuned impedance type, for example, the resonant load on the tube ahead of the coil is L/CR, in which L is the inductance of the coil, C the capacity with which it is tuned, and R the resistance. When tuning is actually done with the inductance by the method discussed, L/R remains constant, and C is a constant. Therefore the load on the tube remains constant. There is nothing then to vary the output for the internal resistance of the tube is also constant, and so is the amplification factor, if we remember that no changes of operating voltages are involved but only a change of frequency.

Therefore, if we tune a circuit by varying the permeability of the space around the coil, we gain constancy of effective selectivity and constancy of amplification throughout the tuning range. Besides, the assembly of a multi-tuner circuit is compact. There is also an increase in the amplification as compared with an air core inductance and capacity tuner. The tuned circuit is designed for the high frequency end where the gain ordinarily is highest. The inductance is then increased to bring in the lower frequencies. Instead of decreasing, the amplification really should increase as the inductance is increased, for it is the exact reverse of capacity tuning. In fact, there is an increase in the gain as the frequency decreases, but the increase is not so large as the increase on the high frequencies when capacity tuning is used. An interesting fact is that the amplification on the low frequencies decreases when the core is grounded, making the gain practically constant throughout the range.

Circuit Shown

Using a 58 tube under normal operating conditions, a dust core coil of 65 microhenries at 1,500 kc, and a fixed capacity of 160 mmfd., the gain per stage was 95 at 700 kilocycles per second, where it was maximum, a gain of 84 at 1,000 kc, and a gain of 81 between 1,100 and 1,500 kc.

In Fig. 4 is shown a circuit diagram of four-tube amplifier - tuner - detector, in which the tuning is done by varying the inductance of the coils. There are six of these coils, one in the input of the first tube, two between the first and the second, two more between the second and the third, and one in the plate circuit of the third tube. The cores are shown at the bottom of the regular coil symbols and they are grounded. The plate voltage connection to the coils is omitted as is also the grid connection when the grid is not returned to the automatic volume control.

The radio frequency gain of a circuit like this is of the order of 500,000, which should be enough under all practical conditions. The selectivity is also very high and remains practically constant for all the frequencies covered by the inductance tuner.

Dimensions of Practical Coils

It was stated that the dimensions of the coil and tuner were small. A coil has been designed having a mean diameter of 3/4-inch, wound with Litz and has an L/R ratio of 14.5 millionths, which makes the Q of the coil at the highest frequency nearly 150. This is very good for a radio frequency coil at this frequency.

While these coils are recommended primarily for tuned radio frequency receivers, they can also be used in superheterodynes. The tracking problem is solved by padding, somewhat in the same way as it is done in capacity tuning. The circuit employed is the Colpitts, which requires only one coil, therefore suitable. A few turns are removed from the coil that is to be used in the oscillator, and then a padding coil is put in series externally to the variable coil field. It is claimed that such an arrangement, properly adjusted, will track with the radio frequency circuits to within 0.1 per cent. The condenser padding method is capable of tracking to about one per cent. of the intermediate frequency. Therefore if the intermediate frequency is 0.1 of the signal frequency, the two are capable of about the same degree of tracking.

There are other ways of tracking. For example, the inner plug can be molded to a different shape than the plug used in a radio frequency tuner. By giving the plug the proper shape, the oscillator could be made to track at any intermediate frequency. Still another way of making the oscillator track is to make the oscillator coil identical with the r-f coils in all respects except that the outer iron dust sleeve is omitted. This decreases the frequency range of the circuit to about 4 to 1, which is about right for an intermediate frequency of 450 kc.

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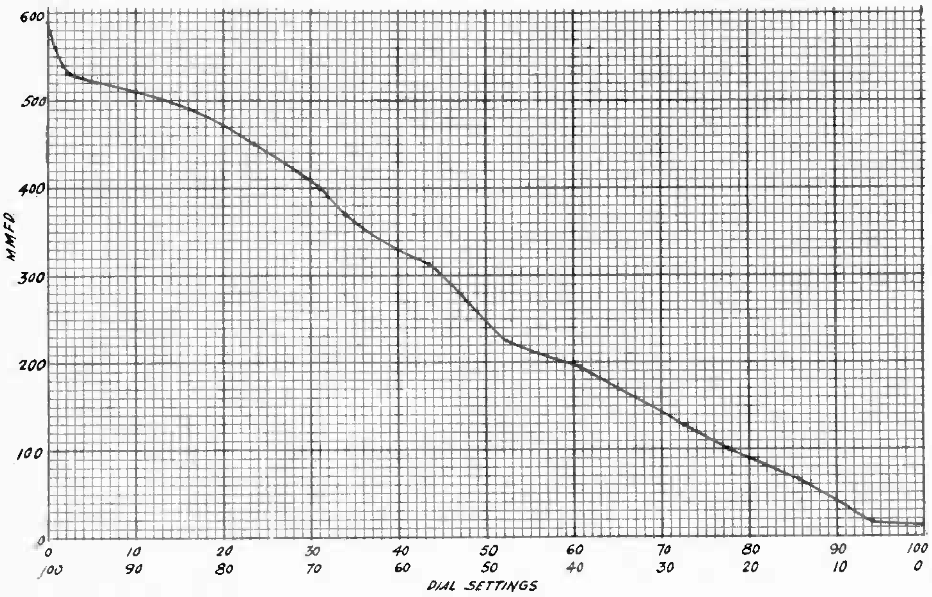


Capacity curve of the G.R. type 247 condenser. Circuit capacities have been excluded, so that the capacities are those of the condenser alone. The values in micro-microfarads are shown at left upright (ordinate), and the dial settings are on the horizontal (abscissa). The condenser is turned to the left for capacity increase. The dial divisions may be 100-0 or 0-100, so both scales are given. To avoid confusion, select the one applicable and ignore the other. It is generally preferable to have higher numerical settings represent higher capacity.

Pair Broadcasting Stations

WHAT is meant by paired broadcasting stations? I have seen this term but there was no explanation of the meaning.—W. T.

Two stations operating on the same wave and using the same antenna are said to be paired when they take turns delivering the signals. The two stations are working all the time but by means of a mechanical distributor they deliver energy to the antenna alternately. This system is in the early experimental stage and there is no definite information on how well it works out. The scheme works very well on land lines and cables for duplex telegraphy and it should work equally well on radio duplex telegraphy. But the problem being investigated is the possibility of using the same system for voice and music. If the change from one to the other could be accomplished fast enough there is no reason why it should not work. But receiving one or the other of the signals would offer difficulties. But that problem, too, is being solved apparently.

* * *

Capacity Curve

CAN YOU GIVE the curve of the General Radio Type 247 condenser, relating capacity with dial settings?—I. D.

The curve is printed herewith. It represents the capacity of the condenser alone at various settings, as other circuit capacities were determined and excluded. Therefore if you are to use the condenser in a tube circuit, the capacity would not be as shown on the curve, but would be greater by the amount added, e.g., tube element capacity, wiring capacity, etc. However, what this amount actually is could be ascertained, by striking a frequency with some random low capacity of the condenser, using a known inductance, and computing the capacity. Subtract the condenser capacity as obtained from the curve to ascertain this distributed capacity. It is preferable to use around 50 mmfd. or so of the G. R. condenser in making this test. The capacity of this condenser runs uniform enough in production to enable use of the curve given, for any but precision measurements. The capacities are actual for sixteen well-distributed points, the rest being extrapolated to yield the curve. The kink near the middle seems to be due to a metal strap in the condenser construction, for although this strap is at theoretically ground potential, in an oscillator any grounded conductor will be grounded actually perhaps at one point, and then a voltage rise in the conductor will take place even over a short span of a few inches. The upsweep of the curve at high capacity (maximum) is due to the shape of the plates and is the opposite to the minimum capacity effect, where there is practically no capacity change for a few divisions.

* * *

How Capacity Meter Works

ON WHAT principle does a capacity meter work, I mean one that is direct reading? I understand how a resistance meter works. Is the capacity meter based on the same principle?—L. M. J.

Yes, you might say that the two work on the same principle, both are based on the reduction of a meter reading, with constant applied voltage, due to the impedance connected in series. When a capacity is to be measured the current must be alternating and the frequency must be taken into account. Suppose you connect an alternating current voltmeter in series with a known voltage and in series with a known capacity. There will be a certain reading on the voltmeter. That corresponds with that capacity. Another capacity can be inserted to get another reading, and so on until a sufficient number of points have been determined to construct a curve, or a scale.

* * *

Electron Coupling

WHAT is the difference between electron coupling and other forms of coupling? How can you tell whether you have electron, inductive, capacitive, or resistive coupling?—W. L. P.

Coupling signifies that there is an impedance common to two circuits. One circuit produces an effect on the other and the effect is mutual. In other words, there is reaction between the two. A mechanical example of coupling is the junction between two railway cars. You can move both cars by putting a motor in either, for there is a reaction between the two. Likewise if two circuits are coupled you can produce currents in both by introducing an electromotive force in either. Electron coupling is unidirectional. If there is an electromotive force in one it will produce a current in the other, but if the electromotive force is placed in the second there will be no current in the first. The reason for this is that electrons will travel in only one way, the potentials being constant as to direction. When they don't know what type of coupling there is, it is customary to call it electron coupling. If you have an oscillator using a 2A7 tube for example, using the inner elements for the oscillator, the current in the plate circuit is varied by electrons shot out from the cathode to the plate. That is electron coupling, for the plate current has little or no effect on oscillation. It was in this connection that the term electron coupling was first used, and the term should be limited to that.

* * *

Air Cell Receivers

WHAT has become of the air cell which we heard so much about a few years ago? Much was promised for it but it seems to have been dropped.—R. T. L.

Air cell receivers are being made for country places. Experimenters are not using the cell because of the difficulty of getting it.

* * *

Simple Padding

WILL you kindly explain how the inductance of the oscillator coil and the series capacity can be computed without going into elaborate mathematics? I understand there is a simple way of going about it.—B.G.F.

Yes, there is a relatively simple way, and it leads to quite accurate results. First assume that at the high frequency end of the dial the series condenser has no effect and that the difference in frequency is due only to the difference betwen the inductances in the oscillator and r-f circuits. Select a high frequency about 100 kc less than the highest to be tuned in, for example, 1,400 kc for the broadcast band. Add to this the intermediate frequency. For example, if the intermediate frequency in the above case is 456 kc, we would have an oscillator frequency of 1,856 kc. Now take the square of the ratio of these, that is, $(1,400/1,856)^2$. This is the ratio of the oscillator inductance to the r-f inductance, assuming the tuning condensers have the same values. The ratio squared in this case is 0.569 and the oscillator inductance is 0.569L, where L is the r-f inductance. Now we are ready to compute the series capacity. Select a low frequency about 50 kc higher than the lowest frequency to be tuned in, say 600 kc. Add the intermediate frequency. We get 1,056 kc. With this frequency and the inductance just obtained, find the total capacity in the oscillator. In the sample case it is $C_0=0.04/L$ mmfd. Find what the capacity in the tuning condenser of the r-f circuit is, using 600 kc and L. It is $C_1=0.0704/L$ mmfd. Now the question is: what condenser must be connected in series with C_1 to make the capacity C_0? We have by the formula for series condensers $C_s = C_oC_1/(C_1 - C_o)$, where C_s is the capacity we are looking for. Putting in the values we have just obtained, we have $C_s = 0.0926/L$. L we get from the tuning condenser in the r-f circuit or from the known inductance of the coil employed in the r-f tuner. Suppose the inductance is 240 microhenries. The series capacity should be 386 mmfd. Then the oscillator inductance should be 136.5 microhenries. This design is close enough for practical purposes for adjustments can be made at the high frequency end by the trimmer and at the low frequency end by the series condenser.

* * *

Tuning by Permeability

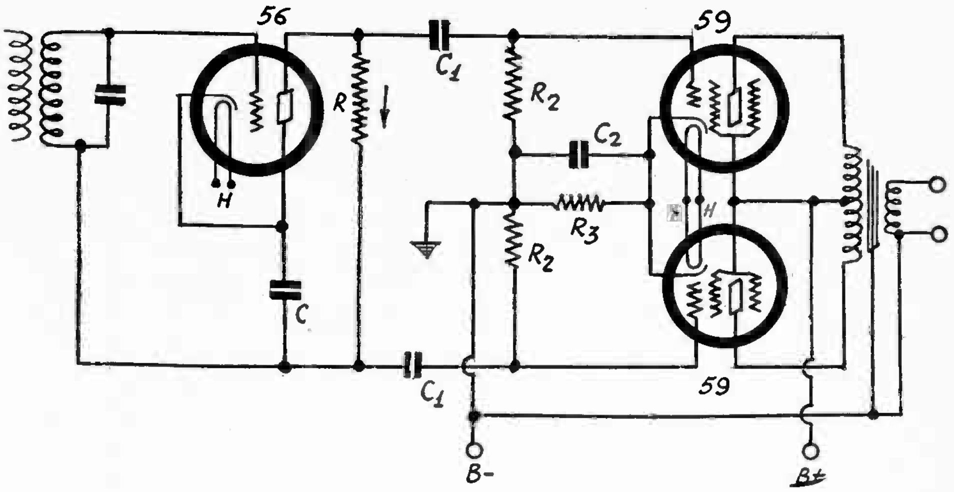
I HAVE problem of constructing an audio frequency oscillator covering the range from 5,000 cycles per second to about 15,000. Tuning is to be continuous. Can you suggest a way of varying the frequency? Incidentally, I plan to vary the frequency in steps by means of condensers but it is between the steps I need a continuous variation.—F. W. K.

If the frequency is to cover this range you will undoubtedly use an iron core transformer, possibly of the open core type. The frequency of an oscillator using such a transformer can be varied continuously by varying the permeability of the core, which can be done by moving part or the whole core with respect to the windings. How this works out you can test by hooking up an oscillator with an air-core transformer and adjusting the frequency so that it is audible. By moving a piece of iron in the field of the coil the frequency will change. It may be that the frequency is too high to be audible when the iron is not near the coil, but when it is inserted the frequency becomes low. But a small variable condenser across the large fixed condensers could also be used. Perhaps that is the simpler way now that we have condensers of many different capacities.

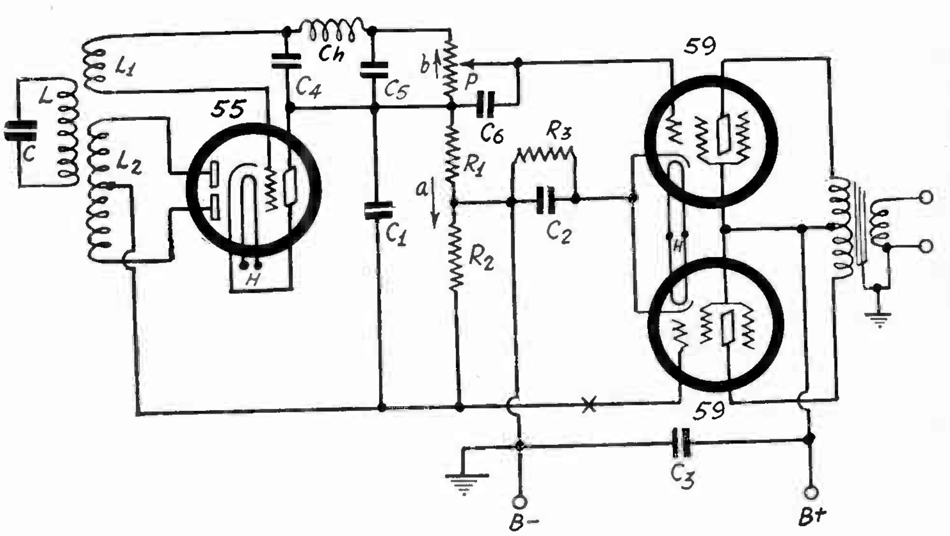
* * *

Two Resistance Push-Pull Circuits

CAN YOU GIVE me some assistance in my experiments with resistance-coupled push-pull? I would like to have a diode feeding the push-pull output pair.—P. V. O'D.



A simple example of push-pull resistance coupling, so called because the voltage across the load resistor R is divided, extremes of R equal in voltage but opposite in polarity, with center grounded either initially, or reflectedly, due to grounding of the juncture of the two R2 resistors. If R is two equal resistors, center actually grounded, the ground on the other side of the stopping condensers C1 is retained.



Stopping condensers are omitted in this diagram, hence this represents substantially non-reactive resistance-coupled push-pull audio. The 55 is used as a full-wave diode detector, while the triode elements are connected as a diode for C bias supply to overcome the positive polarity of the upper 59's grid. In both these circuits constants must yield identical voltage values in both legs.

Here are two diagrams. One shows the simpler form, the 56 used as diode, feeding the output tubes, which must be pentodes, in such an instance, if the sensisivity is to be anywhere near sufficient. An intermediate-frequency transformer, i.e., superheterodyne circuit, is assumed, for that does not have the secondary tuning condenser grounded. The cathode is tied to the erstwhile plate, to constitute the functioning detector cathode, while the erstwhile grid functions as the anode. Hence one end of the secondary is tied to the anode (grid) and the other end goes to one side of the load resistor, R, which may be 0.5 meg. or higher, other side of that resistor to cathode. So we have a direct-current path from anode through secondary through load resistor, to cathode, and through the tube by the electron movement. The center of R may be directly grounded, if R consists of two equal resistors, and then sensitivity is slightly higher. Grounding is effectuated anyway in the grid circuit loads of the 59's, and is reflected back to R, but is not so effective as additional grounding of R at center. The rectified current moves in one direction only, by the extremes of R are equally but oppositely polarized, reckoned from the center of R. Hence only half the rectified voltage across R is utilized at any instant. Stopping condensers connected to succeeding power tube grids, with 1 meg. or more for R2, enable independent biasing of the power tubes, R3 being 400 ohms, and C2 omitted, unless found necessary for stability, when it should be 8 mfd. or more. The other circuit uses the 55 as full-wave diode detector, the triode element as a second diode to buck the upper grid's positive voltage. L and C constitute the tuned circuit, return which is in the plate of the previous amplifier tube. L2 is a tuned or untuned secondary, preferably untuned, as shown. L1 is the auxiliary feed to the C bias supply constituted of the diode-connected triode elements. R1 and R2 are equal, say, 0.1 meg., and P is a potentiometer of higher resistance than either. C4, C5, C6 are 0.0001 mfd., Ch is 10 millihenries, R3 and C2 have values given in the previous example, and C3 is the filter condenser at output of the B rectifier.

* * *

Coupling of Coils

IN A Hartley oscillator I have a coil of 100 turns wound 57 to the inch, 3 inch diameter. The cathode is connected to a point at the exact center of the coil. I want to know what the coefficient of coupling is between the two parts of the coil. I need this not only to study the behavior of the oscillator but also for measurement purpose when the coil is not in the oscillator. How can you figure out the coefficient of coupling in a case like this?—F. G. J.

In this case the coefficient of coupling is 0.413. If you have a table giving the shape factor of solenoids, that is, Nagaoka's constant, then you can compute the coefficient of coupling from the formula $1 + k = K(3/b)/K(6/b)$, where k is the coefficient of coupling, b is the length of the winding, and K is the constant obtained from the table. The length of the coil is the number of turns divided by the turns per inch. The formula applies only when the tap is in the center and when the diameter is 3 inches. One K is obtained for D/b and the other for 2D/b. Then the formula applies for any diameter provided that the tap is in the middle. If you have a book containing curves giving inductance values for different turns and diameters, you can look up the inductance of the total coil and then that of half of it. If L is the total inductance and L1 the inductance of half the coil, the coefficient of coupling is obtained from $1 + k = L2/L1$. This is not quite as accurate because of the difficulty of finding the right inductances from curves.

* * *

Class B Amplifiers

IS IT worth while to install a Class B audio amplifier in a radio receiver that is to be used exclusively in a home, or will the output be too great? What is the best way of installing Class B?—W. G. J.

The only time Class B amplification would be justified in a home receiver is when

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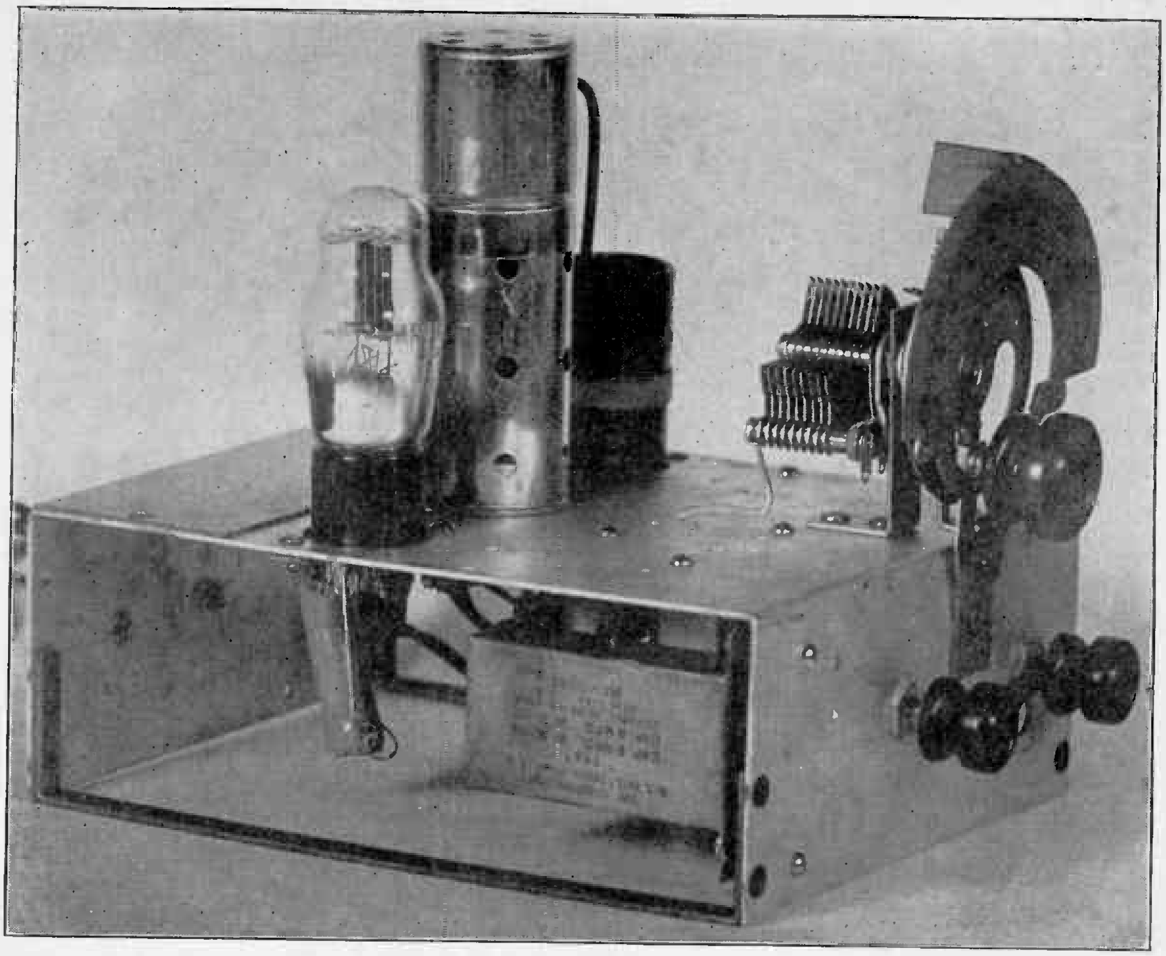


Layout for a universal short-wave set, in which there is one tube for regenerative detector. The other tube is the 25Z5 rectifier. The tuning condenser is in view. The feedback condenser is hidden under the chassis. A B choke and some filter capacity for the rectifier are required.

(Continued from preceding page)

the output tubes are miniature. When regular power tubes are used the output of a pair in push-pull, or even of a single one, is much greater than can be utilized in a home. The Class B amplifier would have to be operated with a very low signal voltage, and under these conditions the distortion would be relatively very high.

* * *

His Temptation

I AM TEMPTED to try a simple short-wave set, consisting of a 39 or 78 screen grid tube as regenerative detector, and a 25Z5 as rectifier, so I shall have universality, but am wondering whether this is all right, and how about the layout?—J. E. D.

The circuit works consistently with the performance of single-tube short-wave battery sets for earphone use, and if your location is at least fairly good your results will be satisfactory. The layout, for use of plugin coils, is illustrated herewith.

* * *

Magnetostriction Oscillator

YOU have never described the construction of magnetostriction oscillators. I am interested in them and should like to know how they work. Can you suggest a way of making one without going into a detailed description?—W. R. L.

Take a piece of monel rod about four inches long. Mount it so that the support is as near the center point as possible. Put a coil over each end, but not so that the coils touch the rod. It is advisable to place a magnetic screen between the two, and this shield can be an iron plate, which may also serve as support. Connect on coil in the grid circuit of a tube and the other in the plate circuit. Suitable coils are those used for 175 kc intermediate transformers, the cores having been removed. The coils should be connected in the opposite direction to that used in other oscillators much depends on the monel metal. While this is generally one of the best for the purpose, not every rod will oscillate. Much also depends on the mounting.

* * *

Tracking or Padding

WHEN the intermediate frequency is 456 kc in a superheterodyne for broadcast reception, which is the better way of keeping the oscillator in line with the r-f circuit, the use of a tracking condenser or padding?—F. R. N.

Padding can be done to an accuracy of about one per cent of the intermediate frequency. That means that when the intermediate frequency is 456 kc, the deviation from perfect tracking need not exceed more than 5 kc. But with improper padding it may be ten times that. When a tracking condenser is used the oscillator should always generate the correct frequency, assuming that the tracking condenser has been designed properly and that adjustments have been done well. But the actual deviation may be just as great when this method is used. Since selectivity is a matter of ratio, it does not matter what the intermediate frequency is. At 100 kc the maximum deviation may be only 1 kc while at 500 kc it would be 5 kc. But the detuning would amount to the same in both instances.

* * *

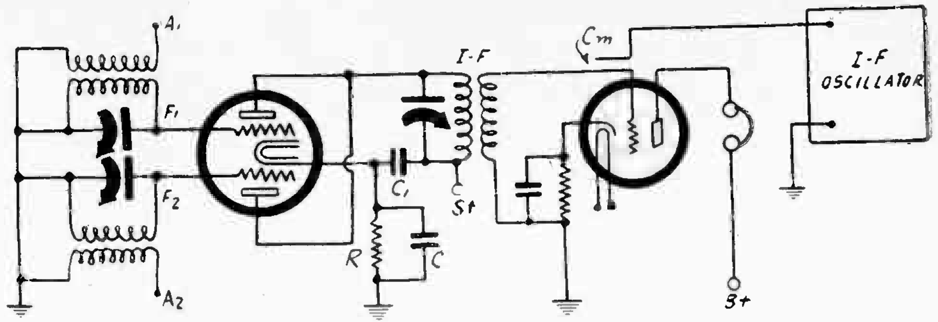
Oscillation in Detector

PERHAPS you can suggest the cause of an oscillation that occurs in my receiver. It appears to be in the final detector. The circuit is of the grid biased type and the grid return is made to ground. In the plate circuit I have a filtering consisting of a choke of about 10 millihenries and two shunt condensers, each of 0.00025 mfd. These are connected in series across the choke and the junction is connected to the cathode. I have a bias resistance of about 25,000 ohms and this is not shunted by any condenser. When I do put a large condenser across it the oscillation ceases. I know the remedy

but I don't know the cause of the oscillation.
—W. H. C.

If you connect a coil between the grid and the plate and two condensers in shunt, that is, one from the plate to the cathode and the other from the grid to the cathode, you have a Colpitts oscillator. You have those conditions, and it is quite possible that the circuit oscillates for that reason. The feedback would be through the bias resistance, the ground end of which is equivalent to the grid. When you put a large condenser across the bias resistance you short circuit the grid input in so far as the oscillator is concerned. If the oscillation also stops when the second of the two shunt condensers is removed, that would be additional evidence pointing to the filter as the cause of the oscillation. But then there might be enough stray capacity to keep the circuit oscillating.

* * *



This circuit shows how it is possible to utilize broadcast stations for calibrating an oscillator against the beat frequency of two transmitters. High accuracy is possible because the stations are accurate.

Utilizing Beats Between Stations

WILL YOU kindly show a circuit suitable for the calibration of an intermediate frequency oscillator by utilizing the beats between broadcast stations? I imagine that this is possible and that high accuracy of the beat will result, since nearly all broadcast stations are closely controlled as to frequency.—R. L. B.

You will find a suitable circuit on this page. It is about the simplest arrangement that can be used, but in some locations it may be necessary to amplify the signals before they are impressed on the mixer tube. This tube is a duplex amplifier such as the 53. There are two input circuits, each tuned to one of the beating frequencies. The two plates of the tube are tied together and an intermediate-frequency transformer is connected in the circuit to pick out the beat frequency before it is impressed on a detector tube. The oscillator to be calibrated is very loosely coupled to the grid of the detector tube by a small capacity Cm. The intermediate coupler must be tunable and it should cover the same range as the oscillator to be calibrated. Tune the two radio frequency circuits to any two broadcast stations differing in frequency by the amount desired. Find the corresponding setting of the oscillator by the zero beat (between the first beat and the oscillator frequency). When one point has been found select stations that give another frequency, or one other station and one that is already tuned in. By this means any oscillator can be calibrated in steps of 10 kc from about 10 kc to 1,000 kc., provided, of course, that the radio-frequency receivers are sensitive enough to pick up enough stations.

* * *

Distortion in Resistance Coupled Amplifiers

ARE all audio frequencies really amplified to the same degree in a resistance capacity coupled amplifier, or do the condensers cause discrimination? If so, to what extent and which frequencies are suppressed?
—R. L. B.

There are two effects which cause differences in amplification. First, there are the tube capacities which are in shunt with the coupling resistors and for that reason reduces the amplification of the high frequencies. Second, there is the grid stopping condenser, which reduces the amplification on the low frequencies. Therefore the coupler is in effect equivalent to a very broadly tuned circuit in which there is one frequency at which the amplification is maximum. Just what effect the shunt capacities have in suppressing the high frequencies depends on the values of the capacities and also on the values of the coupling resistance and grid leak. The higher the resistances the more the high notes will be suppressed. What effect the series condenser has in suppressing the low frequencies depends on its capacity and also on the value of the grid leak resistance. The greater the product of the grid leak resistance and the capacity, the less will the low notes be suppressed. In order to make the circuit amplify all audio frequencies to about the same degree, the stopping condenser capacity should be large and the shunt condensers should be small. High mu tubes and screen grid tubes have higher input and output capacities than low mu triodes. Therefore when high quality is essential low mu tubes should be used, that is, general purpose tubes. It is permissible to use higher plate resistance and grid leak with low mu tubes than with high mu tubes, and since high resistance also improves the wave form, we have another reason for using low mu tubes.

* * *

Type of Oscillator for Super

For a time the 57 and 58 tubes were used as oscillators and mixers in superheterodynes in such a manner that the tuned oscillator circuit was put in the place circuit of the tube and the grid coil in the cathode lead. Is not this a better way of mixing than the method employing the 2A7? What do you consider the best way of producing the oscillation and of mixing?—W. H. L.

Whether you use the 2A7 or similar tube or a 58 in the manner mentioned makes comparatively little difference. However, of the two the 2A7 is the better because it is more reliable. Any mixer should have an oscillator that is free from harmonics and the coupling between it and the detector should be such that only the fundamental is impressed on the mixer. Moreover, the voltage from the oscillator should not overload the detector, for if it does there will be all kinds of harmonics in the output of the mixer. It is always well to have a means for controlling the signal voltage from the oscillator that is impressed on the mixer.

* * *

Decrease of Permeability

WHY DOES the apparent permeability of an iron core decrease as the frequency of the magnetizing current increases? Is not the same iron in the magnetic circuit all the time?—W. B. J.

The reason the apparent permeability decreases is that as the frequency increases the magnetization is confined to the surface of the core material. In other words, the higher the frequency the less of the iron takes part in the magnetic circuit. It is for the same reason that the resistance of a conductor increases with the frequency. A magnetic field is set up inside the wire and the current is limited to the surface of the wire. This is the so-called skin effect. But the skin effect in the core also limits the hysteresis losses because not so much of the iron is magnetized

ONE-TUBE ROCKET
A Simple Set for Short Waves

By Herman Cosman
Try-Mo Radio Corporation

HERE is a small short-wave receiver for those who want to experiment with reception from foreign countries without going to a great deal of expense. The circuit is regenerative and is equipped for earphone listening only.

But why use earphones for short-wave reception when the signals can be had on a loudspeaker? Well, if loudspeaker reception must be had on the short waves, the output of this simple circuit can always be impressed on the audio amplifier in the broadcast set, and then there will be plenty of sound. But the main reason for using a headset is that listening in is often done at hours when the sound from a loudspeaker is objectionable to neighbors. Sometimes, also, one member of the family may be interested in short wave listening while the rest want to listen to the broadcast stations.

With earphones the short-wave fan can listen all he wants to and he will not interfere with the enjoyment of the other members of the family. Neither will the loudspeaker of the broadcast set interfere appreciably with the short wave receiver, for the phones would be clamped to the ears and little noise could enter.

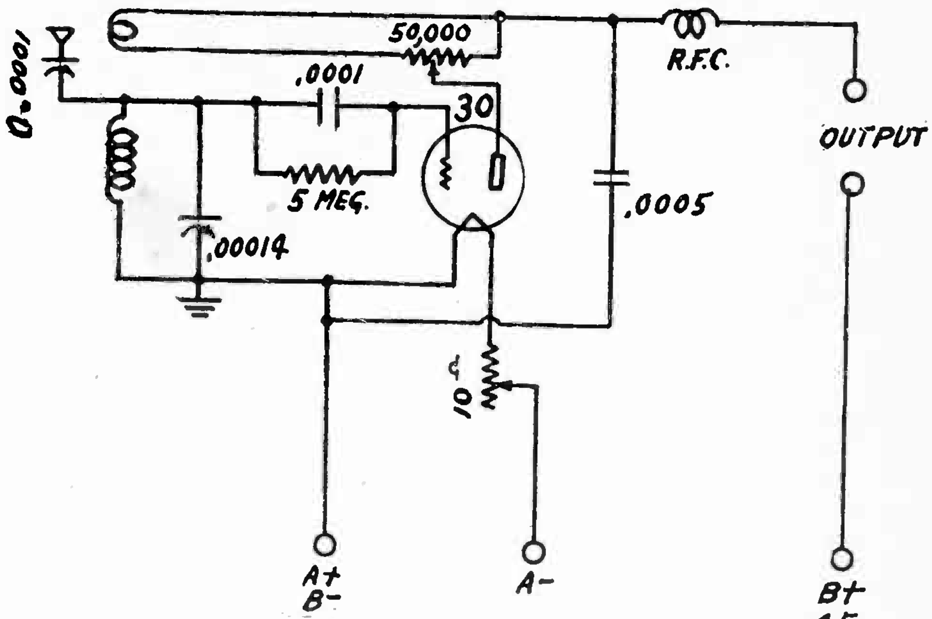


FIG. 1

The circuit diagram of the Rocket one-tube, short-wave receiver. It is of the regenerative type and employs a single 30 tube. The set of coils for the circuit covers the band from 15 to 200 meters.

The Circuit

The circuit of this short-wave receiver is about the simplest that could be used, for there is only one tube, and that is a midget. For sensitivity control there is a 50,000-ohm potentiometer for controlling the feedback. The slider of this potentiometer is connected to the plate of the tube, and the potentiometer resistance is connected in shunt with the tickler coil.

As will be noticed, when the slider is at the extreme right, that is, at the choke end, there is no feedback, for the plate signal current goes directly to ground through the 500 mmfd. by-pass condenser.

On the other hand, when the slider is over on the left end of the resistance practically all the plate signal current goes through the tickler coil, for the potentiometer would have a very high impedance as compared with the impedance of the tickler coil. If then the circuit oscillates at all settings of the tuning condenser when the slider is over on the left end of the potentiometer, full regeneration is possible on all frequencies, and the proper setting of the potentiometer will always be at some intermediate position.

Object of R-F Choke

The purpose of the radio-frequency choke is to prevent the headphones from being at a high radio frequency potential, that is, it is to eliminate body capacity. Its usual purpose is to prevent by-passing of the radio frequency currents before they have gone through the tickler but in this circuit the unused portion of the potentiometer serves that purpose. By unused is meant that portion which is between the choke and the plate. It will be noticed that the effective plate voltage varies as the regeneration is controlled. It is greatest when the potentiometer slider is at either end of the resistance, and least when the slider is at the middle point. This is a desirable feature, for it makes the resistance in the plate circuit highest when the slider is at the point where it will usually be. A high resistance in the plate circuit not only makes the control of the regeneration better but it also makes the tube more efficient as an audio amplifier.

The Tuner

A small variable condenser, one of 100 mmfd., is put in the antenna circuit for the purpose of varying the effective length of the antenna, and thus to bring out the highest sensitivity. It also serves to loosen the coupling between the antenna and the tuned circuit, which makes for higher resonant voltage across the tuned circuit and greater effectiveness of the regeneration.

For tuning the coil a 140 mmfd. condenser is employed. This is equipped with a large vernier type dial, making close tuning practical and easy.

As a further means of controlling the regeneration and the gain, a 10-ohm rheostat is put in the filament circuit of the tube. Normally, this should be set at maximum resistance value unless the filament battery is nearly exhausted. Then the resistance can be reduced to extract the last bit of life from the cells.

Grid leak and condenser type detection is employed, which is just another name for diode detection with diode bias on the audio amplifier. For load resistance on the diode, that is, grid leak, a resistance of five megohms is employed, which is high enough to insure a high rectification efficiency. The resistance is shunted with a condenser of 100 mmfd., which is large enough for the high frequencies which will be impressed on the tube.

LIST OF PARTS

Coils

One set of four plug-in coils wound for 15 to 200 meters
One radio frequency choke

Condensers

One 140 mmfd. Hammarlund variable condenser
One 100 mmfd. variable condenser
One 500 mmfd. fixed mica condenser
One 100 mmfd. fixed mica condenser

Resistors

One 50,000-ohm potentiometer
One 5-megohm grid leak
One 10-ohm rheostat

Other Requirements

One panel and base, drilled and punched
One coil socket
One 30 socket
One antenna and ground binding post strip
One phone binding post strip
One kit of assorted hardware
One roll hook-up wire
One four-wire cable
Two knobs
One 4-inch tuning dial
Complete instructions for wiring

The Power Supply

Very little power is required to operate this circuit. The single tube employed, a 30, takes only 60 milliamperes on the filament, and this can be supplied for long periods by a small dry cell. A pair of No. 6 dry cells would last a very long time, and it would, perhaps, be more economical to use smaller cells. Three volts should be applied across the terminals for the A battery. The plate voltage required is only 45 volts, which can be supplied by a very small battery.

In using a simple set like this the time for listening in should be selected carefully, at least at the beginning before the operator has learned the peculiarities of the circuit. Short waves do not come in equally well at all hours of the day. There are several reasons for this. First of all, if the stations are European, the difference in time must be taken into account. Europe is five and six hours ahead of New York and other Eastern places, the time difference depending on where in Europe the transmitting station is located. Also, they do not broadcast at all hours. In terms of Eastern Standard time, the best signals from Europe come in the afternoon and early evening. Another reason is that waves do not travel equally well at all hours, nor do the same waves travel equally well at all hours.

Station Sparks

By Alice Remsen

SOME CHANGES HERE AND THERE

Phil Cook, the "one-man show," will be on the opening program of the Silver Dust Serenaders—this is a new tri-weekly program—Tuesdays, Thursdays and Saturdays, WABC, 7:30 p.m. . . . Connie Gates is now being featured with Mark Warnow's Orchestra, Thursdays at 10:45 p.m. . . . Georgie Jessel's half-hour program has been switched to Tuesday nights; now the inimitable Georgie, with Freddie Rich's Orchestra, the Eton Boys and Edith Murray, may be heard over WABC each Tuesday at 9:30 p.m. . . . Very glad to hear that Jimmy Kemper will be featured on the "Music in the Air" program, with Bob Armbruster's Orchestra, each Monday, Wednesday and Friday at 7:30 p.m. Jimmy has a new style of song-dramatizations to give the radio fans, in which he will be assisted by Neil McFee, well known Broadway actor; a male octet and the Humming Birds trio will also be heard. This series is sponsored by the Tidewater Oil Company and is heard over WABC and a network of eighteen stations.

JULIA AND FRANK ON THE ROAD

And so it's "the road" again for Julia Sanderson and Frank Crumit! With the New Year these two veterans of stage and radio opened in vaudeville and their home, "Dunrovin," will be theirs in name only for a while. They will still be heard over WABC, however, each Sunday at 5:30 p.m. on their Bond program. . . . Nino Martini made his debut on the Metropolitan Opera stage singing the role of the Duke in Verdi's "Rigoletto." The handsome young tenor received numerous ovations in response to his rendition of the principal arias, taking as many as twenty curtain calls in the last act. Lily Pons played opposite him in the role of Gilda, and it was a general comment among the audience that never before had a couple so fitted to the romantic roles of "Rigoletto" appeared on the stage of the "Met.". . . Patricia Dorn decided to take advantage of New York's recent snowstorm and get out her ice-skates; consequently, Patricia appeared at the studios limping with her strained ankle beautifully bandaged; evidently Pat is better at the "mike" than on the ice. . . . Gypsy Nina and Gertrude Neissen staged a sleigh-driving contest in Central Park last week; Gertie won by a nose. . . .

MARY EASTMAN BACK AGAIN

Mary Eastman, beautiful and gifted young soprano, returned to the Columbia network last week; she will be heard on weekly broadcasts with Howard Barlow and his orchestra each Friday at 10:45 p.m. Miss Eastman will devote herself to operatic arias, concert numbers and occasional musical comedy numbers. . . . Colonel Stoopnagle and Budd, who were recently appointed Colonels on the staff of Governor Ruby Laffoon of Kentucky, received their commissions last week bearing the full names of the Colonels, Hon. F. Chase Taylor and Hon. Wilbur Budd Hulick. With the commissions Colonel Stoopnagle and Budd received a letter from "General" C. C. Pettijohn, commander of all the Kentucky Colonels, containing a very fine offer; the "General" said if they would attend the next Kentucky Derby, he would give them the name of a horse that is guaranteed to finish not worse than ninth. . . . Julia and Frank (Crumit and Sanderson) have started their fourth year of broadcasting over the same network for the same sponsor. Not so bad, what! . . . Babe Ruth has started a series of electrical transcription programs over WOR. The program will be in the nature of a boys' club, and may be heard each Monday, Wednesday and Friday evening at 6:30 p.m. Prizes will be awarded each week. . . .

THOSE TYPEWRITER BOYS

A new program called "The Magazine of the Air" will be heard on WOR each Wednesday at 9:00 p.m. Five leading journalists will be featured—Heywood Broun, Gilbert Seldes, Sigmund Spaeth, Alice Hughes and Jack Kofoed. News of the hour will be dramatized in the opening of every program, with four or five episodes being used. Seldes will provide the editorial comments as well as reporting news of the theatres and the motion picture world; humorous observations will be broadcast by Broun; Miss Hughes will voice things of interest to women; Kofoed will confine himself to current events of the sports world; and Doctor Spaeth is to give a digest of the latest in music and will use the WOR house orchestra for demonstrations. . . . Sally and Sue are still broadcasting each Monday, Wednesday and Friday at 2:15 over WOR, and are receiving quite a lot of audience mail with requests for little known songs. . . . There is a new weekly series on WEAF, Sundays at 3:30 p.m. featuring Richard Himer's Orchestra, Francis Langford, and the Three Scamps. . . . And Jack Pearl replaced Bert Lahr on those Wednesday night programs over WEAF at 8:00 p.m. . . .

DROP ME A LINE

Your faithful scribe has opened on a new series over WEAF each Wednesday morning at 11:15 E.S.T., over the following stations: WEAF, New York; WTAG, Worcester, Mass.; WEEI, Boston, Mass.; WGY, Schenectady, N. Y.; WBEN, Buffalo, N. Y.; WCAE, Pittsburgh, Pa.; WTAM, Cleveland, Ohio; WWJ, Detroit, Mich.; WSAI, Cincinnati, Ohio; KYW, Chicago, Ill.; KSD, St. Louis, Mo.; WDAF, Kansas City, Mo.; WCSH, Portland, Me.; WSM, Nashville, Tenn.; WTMJ, Milwaukee, Wis.; WEBC, Superior, Wis.; WMC, Memphis, Tenn.; WSB, Atlanta, Ga.; WAPI, Birmingham, Ala.; WSOC, Charlotte, N. C.; WSMB, New Orleans, La.; KTHS, Hot Springs, Ark.; KVOO, Tulsa, Okla.; KPRC, Houston, Texas; WOAI, San Antonio, Texas; WKY, Oklahoma City, Okla.; KOA, Denver, Colo.; WJAR, Providence, R. I.; WFBR, Baltimore, Md.; WLIT. Phila.; WRC, Washington, D. C.; WHOM, Rochester, N. Y.; WOW, Omaha, Neb.; WBAP, Fort Worth, Texas, and KDYL, Salt Lake City, Utah. Hope you'll turn the dial my way and take a listen—if you like it—well, listen again on the following Wednesday; if you have a favorite song you'd like to hear me sing, drop me a line and I'll try to do it for you; address me Station WEAF, Rockefeller Plaza, New York. Thanks! . . .

OVER THE RADIO FIELD

Jean Sargent has left radio for pictures. . . . Rube Goldberg, the cartoonist, James Melton and Al Goodman's orchestra have signed a contract for a new commercial series over NBC. . . . Very sorry to hear that the wife of Will Donaldson, the accompanist and arranger for Men About Town, passed away last week. . . . Lulu McConnell will be back on the air again soon, and perhaps for her old sponsor. . . . WLS, Chicago, refused to link up with NBC on the two-hour opera broadcast. Perhaps they used good judgment: there are many listeners who would not care for such a strong dose of highbrow entertainment but would rather listen to a comedian, popular singer, or even a political speaker; it would be a dreary world if we all had the same tastes. . . . The reason Lennie Hayton was off the Crosby show for a time was "union trouble;" that sort of trouble is not always confined to "Cloaks and Suiters;" the musicians' union is one of the strongest in the country. . . . The radio slogan nowadays seems patterned after Kingsley's Westward Ho! Among those to make a long trek westward are Ruth Etting, Morton Downey, Guy Lombardo, Phil Regan, Rudy Vallee, Alice Faye, Bing Crosby, Lennie Hayton, Burns and Allen, Lanny Ross, Ted Husing and Kate Smith. . . .

A THOUGHT FOR THE WEEK

WHEN FRANK CRUMIT and JULIA SANDERSON came on the air you may be quite sure that you are not going to hear anything off-color or a word, line or thought which you might hesitate to explain to the youngsters; and yet they talk and sing for the adult mind also—but their record on the stage and in radio is as clean as it is interesting. Their General Baking Co. and Blackstone programs have always been notable for cheerfulness and warmth and human interest.

Mr. Crumit and Miss Sanderson, we salute you and express the wish that you will be on the air for many years to come and continue to prove that wit and humor and music may be joined together without ever transgressing the good taste and wholesomness which are yours in a superlative degree.

OUTSTANDERS IN 1933

Among the outstanding events of the year 1933 in radio broadcasting were: President Roosevelt's Inauguration, a world-wide broadcast on March 4th; George Bernard Shaw's talk in the United States from the Metropolitan Opera House on April 11th; the description of Wiley Post's arrival after his around-the-world flight on July 22nd; the two-way conversation of Maxim Litvinoff from the White House to his wife in Moscow, November 17th; the Settle-Fordney broadcast from the stratosphere, November 20th, and the Christmas greetings from King George, which were short-waved around the earth on December 25th. There are others which have slipped my memory, but the foregoing were wonderful enough. . . .

LET'S ALL HOPE

I am writing this on New Year's Eve. I can't go out to a party because I'm on the air twice on New Year's Day—at ten a.m. over WEAF and 2:15 p.m. over WOR. So my New Year's Eve consists of just listening to the dancing parties being broadcast for somebody else to dance—and sitting at a typewriter pounding this out for you to read. But I don't mind; the main thing is to work on New Year's Day, which is quite a superstition among theatrical folk; they say if you work and make money on New Year's Day you'll do the same thing all the year round, and here's hoping we all do just that!

Using 2A3 to Best Advantage in Push-Pull

(*Continued from preceding page*)

are designed for use with typical commercial power transformers. There are no special features involved in the design of the power transformer. Any make of transformer having the appropriate voltage windings, correct rating, and good regulation may be used.

Pre-Amplifier Stage

A type 56 tube is used in the pre-amplifier stage, since this tube gives excellent power sensitivity. The 56 also is an economical type.

A plate-supply voltage of 200 volts for the 56 is adequate to give the output signal required to swing the 2A3's. This is the voltage available for plate supply to the other tubes in the set under conditions given in Figs. 1 and 2. The 56, with 20-volt plate supply, is operated with a bias of minus 11 volts. The plate current is 3.6 milliamperes.

The same input transformer, specifications for which are given later, is used for both the semi-fixed and fixed-bias arrangements. Commercial-size audio-transformer laminations are used.

The ratio of the input transformer is 1.4 to 1 from the full primary winding to one-half of the secondary winding. The peak voltage which will be induced in the secondary winding is 2x90 or 180 volts at the point at which the 56 begins to draw grid current.

In determining the constants for the input transformer, cost, size, response characteristics, and signal requirements must be considered. In order to obtain a low-cost small-size transformer with primary inductance high enough to give good frequency characteristics, a step-down ratio is used. A step-up ratio would require a larger transformer design in order to provide space for the additional secondary turns. However, under the circuit conditions shown, the step-down ratio can give a signal input to the 2A3's sufficiently large to obtain their full output.

Transformer Specifications

POWER TRANSFORMER S-79A*

Core:
Material—Transformer Steel, Allegheny Steel Co. or equivalent
Punching—EI—13A
Stack—1¾" Weight—4.9 lbs.
Primary
Resistance—2.4 ohms
Secondary
Resistance at 25°C.—2x106 ohms
Induced voltage—2x375 volts RMS
Induced voltage from center tap to tap for bias rectifier—approx. 57 v. RMS.
Total weights of copper—1.0 lb.

INPUT TRANSFORMER S-77*

Core:
Material—Audio B, Allegheny Steel Co. or equivalent
Punching—EI—75 Stack—¾"
Joint—Butt Weight—0.6 lb.
Primary:
Turns—5000
Location—Between two halves of secondary winding
Turns per layer—240 Layers—21
Insulation between layers—0.001" paper
Wire—No. 40 enamelled
Resistance at 25°C.—2000 ohms
Secondary:
Turns—Two windings of 3,600 turns each
Location—One-half over, one-half under primary
Turns per layer—240
Layers—2x15
Insulation between layers—0.001" paper
Wire—No. 40 enamelled
Total weights of copper—0.14 lb.

CHOKE S-26*

Core:
Material—Dynamo Steel—Allegheny Steel Co. or equivalent
Punchings—EI—12 Stack—1¼"
Air gap—0.004"x 2 Weight—1.88 lbs.
Winding:
Turns—1780 Turns per inch—81
Layers—22
Insulation between layers—0.003" paper
Resistance at 25° C.—approx. 60 ohms
Weight of copper—0.47 lb.
Inductance—approx. 10 henries (conditions as in Fig. 2)

Westinghouse's Chief Confident of Ultimate Prosperity for Industry

By A. W. Robertson
Chairman, Westinghouse Electric & Manufacturing Company

The United States Government is spending three billion, three hundred million dollars on public works. In 1932 the American people, at the bottom of the depression, spent approximately four hundred billion dollars. These figures are startling.

We see how much more important individual and corporate spending is than Governmental spending. A 10% increase in what the consumer, corporate and individual, spends would amount to forty billions of dollars, or more than ten times the amount the Government is spending on public works. A comparison of this nature shows definitely that the normal exchange of goods and services by persons and corporations is the base upon which business and business recovery must rest. Government cannot by spending or by law create good business. It can feed us and clothe us, perhaps, for a time but it cannot legislate prosperity.

As far as the electrical industry is concerned, it faces the new order confidently. Its resources have been conserved, its technical progress has been uninterrupted, research has discovered many new uses for electricity and new devices have been developed for its utilization.

When capital goods business finally yields to the many forces now being exerted for its improvement, the electrical industry cannot fail to benefit and again resume its rightful place as one of our most essential and most prosperous industries.

Copper Oxide Disc Is Sensitive to Light

A layer of copper oxide on a copper disc has some unusual and interesting properties. Many of us are familiar with the Rectox or copper oxide rectifier which has been widely used for several years. The Photox might be called the cousin of the Rectox. It too is a copper disc with a coating of oxide but instead of rectifying it acts as a tiny primary battery when light strikes its surface. The current generated is measured in micro-amperes but is sufficient to be extremely useful.

The current output is directly proportional to the intensity of the light which strikes it and retains this property indefinitely. Its response to colored light is another interesting characteristic. The response is almost exactly the same as that of the human eye. A colored light which seems bright to the eye seems bright to the Photox. It has become the basis of the light intensity meter and the transparency meter (transometer).

New Surge Limiters and Indicators of Modulation Impending

Plant managers of KYW, Chicago, and other Westinghouse stations met at Chicopee Falls, Mass., to discuss changes in operating procedures and problems arising from operation under the code of fair competition for the Broadcasting Industry.

The group visited the WBZA transmitter in East Springfield, which has just recently been remodeled, and the transmitter and studios of WBZ, which has been granted permission to operate on 50 kw. In Hartford the group visited WTIC and met its engineers and also representatives of the Travelers Insurance Company to discuss safety measures. A trip was made through the Radio Division plant at Chicopee Falls.

Business discussed included the design of new apparatus to be manufactured for stations. Surge limiters and modulation indicators of a novel design are soon to be installed at the stations to allow higher percentage modulation without distortion.

Hanson Inspects NBC

O. B. Hanson, manager of technical operations and engineering for the National Broadcasting Company, New York, is inspecting the various NBC division headquarters in San Francisco.

As he had been in charge of the designing and construction of the studios in Radio City, Hanson had not been able to make his usual annual tour of inspection for the past three years.

Hanson will inspect the new 50,000-watt transmitter at KPO, San Francisco, and the 50,000-watter which is under construction at KOA, Denver. He also will inspect NBC division headquarters in Chicago and Cleveland.

Hanson has between 500 and 600 radio engineers under his direction.

New Portable Oscillograph

A new portable oscillograph by Westinghouse compares in size and sturdiness with portable instruments. It measures 11½" x 11" x 8", weighs 22 lbs., requires no external auxiliaries and operates from a 110 volt lighting circuit. While it fills a need for a simple low-cost unit it does not replace the more expensive and complete equipment.

A ray of light passes through a new optical system which permits viewing and photographing at the same time and which magnifies the galvanometer deflection. The 2½" x 3½" viewing screen shows a brilliant trace which is clearly seen even in broad daylight and photographing a wave form is much the same as taking a picture with an ordinary camera. A standard Graflex film, 2¼" x 3¼" is used for photographic purposes.

OUTPUT TRANSFORMER S-84*

Core:
Material—Audio C, Allegheny Steel Co. or equivalent
Punching—EI-11
Stack—⅞"
Joint—Lap Weight—1.0 lb.

Primary:
Wire—No. 32 enamelled
Turns—1400 tapped at 700
Location—Next to core
Turns per layer—105
Layers—14
Insulation between layers—0.0015" paper
Resistance at 250° C.—98 ohms

Secondary:
Turns—No. 32
Location—Wound over insulated primary
Wire—No. 15 enamelled
Turns per layer—16 Layers—2
Insulation between layers—0.005" paper
Secondary load—Voice coil of electro-dynamic speaker having an impedance at 60 cycles of 1.06 ohms

OUTPUT TRANSFORMER S-105*

Core:
Material—Audio C—Allegheny Steel Co. or equivalent
Stack—0.875"
Joint—Lap Weight—1.0 lb.
Primary:
Turns—2000 tapped at 1000
Location—Next to core Wire—No. 33 enamelled
Turns per layer—118 Layers—17
Insulation between layers—0.0015" paper
Resistance at 25°C.—172 ohms total
Inductance—195 henries (at full signal)
Secondary:
Location—Wound over primary
Turns = 2000 divided by the square root of $[5400/(R_1 + r_2)]$
where,
R_1 = external load resistance on secondary terminals
r_2 = resistance of secondary winding or approx. 6% of R_1
Resistance at 25°C.—0.053 ohms
Output—13.3 watts into a 1.06-ohm load at 60 cycles
Total weight of copper = 0.24 lb.

*Our design identification number.

175 KC TUNING UNIT FREE

WITH SUBSCRIPTION

For use with 175 kc intermediate frequency. Unit includes four-gang condenser, three r-f coils, the proper oscillator inductance and 800-1,350 mmfd. padding condenser. Send $12.00 for two-year subscription and order Cat. SUTU-175, which will be sent postpaid.

Radio World
145 West 45th Street
New York City

Vest Pocket Size Flashlight for Radio Repair Work—FREE

Great for getting right down into your set!

Obtain one free with 3 months' subscription for Radio World at the regular rate of $1.50. Send postpaid.

Sub. Dept.
RADIO WORLD
145 West 45th Street New York, N. Y.

Quick-Action Classified Advertisements

7¢ a Word—$1.00 Minimum

DEALERS, SERVICE MEN AND AGENTS. Latest Crusader Midget Radios, $5.85. Write for full particulars. Chicago Radio Distributors, 1325 S. Michigan, Dept. 22, Chicago.

RED HOT RADIO SERVICE IDEA. Will bring business. Only one to territory! $1.00 postpaid. F. Deming, 1233 No. 42nd St., Lincoln, Nebr.

"AUTOMOBILE REFINISHING," by C. E. Packer, Member of S.A.E. For the car owner and professional refinisher. A practical handbook on the materials, methods and equipment used. 148 pages, 41 illustrations. Price $1.50. RADIO WORLD, 145 W. 45th St., New York City.

"THE FORD V-EIGHT—'B'-FOUR—'BB'-TRUCK," by C. B. Manly. A New and Practical Book for Everyone Interested in the Construction, Adjustment, Upkeep and Repair of The New Fords. Over 250 pages, 125 illustrations. Complete cross index. Pocket size, flexible leatherette cover. Price $2.00. Radio World, 145 W 45th St., New York, N. Y.

MODERN TUBE INDEX, all tubes, all the dope, all manufacturers, socket connections, everything. Most complete of all. Sheet 21 x 27 inches. Price 25c. RADIO WORLD, 145 West 45th Street, New York, N. Y.

"THE CHEVROLET SIX CAR AND TRUCK" (Construction—Operation—Repair) by Victor W. Pagé, author of "Modern Gasoline Automobile," "Ford Model A Car and AA Truck," etc., etc. 450 pages, price $2.00. Radio World, 145 W. 45th St., N. Y. City.

"MODERN ELECTRIC AND GAS REFRIGERATION," by A. D. Althouse and C. H. Turnquist. A timely book of practical and usable information on installation, service, repair of all types of automatic refrigerators. 275 pages, 175 illustrations, diagrams in six and eight colors. Price $4.00. RADIO WORLD, 145 W. 45th St., New York City

"RADIO TROUBLE SHOOTING," Second Edition, by E. R. Haan. Contains the latest on A.C. receivers, dynamic speakers and television. A practical book for practical men. Contains a special chart showing all possible radio troubles and the way to detect them. Size 6 x 9 inches. 361 pages, 300 illustrations. Flexible binding. Price $3.00. RADIO WORLD, 145 W. 45th St., New York City.

Valuable Gifts with Subscriptions for RADIO WORLD

A *NEW* TEST OSCILLATOR

That Works A.C., D.C., or Batteries!

SHOWN ONE-THIRD ACTUAL SIZE

Over-All Size Is Only 5x5x3"! Dial Reads Frequencies Directly!

A NEW TEST oscillator, Model 30, has been produced by Herman Bernard, so that all the requirements for lining up broadcast receivers, both tuned radio frequency and superheterodyne types, will be fully and accurately met. This device may be connected to 90-120-v a.c., any commercial frequency, without regard to polarity of the plug, and will function perfectly. It may be used also on 90-120-volt d.c. line, but plug polarity must be observed. One of the plug prongs has a red spot, denoting the side to be connected to positive of the line. If you don't know the d.c. line polarity, you may connect either way, without danger. The oscillator will work on d.c. only when the connection is made the right way. Moreover, 90 volts of B battery may be used instead of either of the foregoing, simply by connecting two wires between the plug at the batteries, observing polarity. No separate filament excitation is required. The oscillator is modulated with a strong, low note under all circumstances. It uses a 30 tube.

THE dial of the Bernard Model 30 Test Oscillator is directly calibrated in kilocycles, so there is no awkward necessity of consulting a chart. The fundamental frequencies are 135 to 380 kc, so that nearly all commercial intermediate frequencies as used in present-day superheterodynes are read on the fundamental. The points for other intermediate frequencies, e.g., 400, 450, 456 and 465 kc, are registered on the dial also, two harmonics, with which the user need not concern himself, being the basis of these registrations. Besides, the broadcast band is taken care of by the fourth harmonic and the dial is calibrated for that band, also.

The divisions on the dial for the fundamental band, 135 to 380 kc, are 1 kc apart from 135 to 140 kc, 2 kc apart for 140 to 180 kc and 5 kc apart for 180 to 380 kc. For the broadcast band, 10 kc apart from 550 to 800 kc, 20 kc apart from 800 to 1,500 kc.

The test oscillator may be used also for short waves, by resorting to higher harmonics.

Send $12 for 2-year subscription for RADIO WORLD and order Cat. BO-30 sent free, with tube (prepaid in United States and Canada).
Another model, BO-30-S, same as above, except frequencies are ten times as high, hence instrument is for short-wave work only, is available on same basis.

"The Inductance Authority"

By EDWARD M. SHIEPE, B.S., M.E.E.

THE ONLY BOOK OF ITS KIND IN THE WORLD, "The Inductance Authority" entirely dispenses with any and all computation for the construction of solenoid coils for tuning with variable or fixed condensers of any capacity, covering from ultra frequencies to the borderline of audio frequencies. All one has to do is to read the charts. Accuracy to 1 per cent. may be attained. It is the first time that any system dispensing with computation has achieved such very high accuracy and at the same time covered such a wide band of frequencies.

A condensed chart in the book itself gives the relationship between frequency, capacity and inductance, while a much larger chart, issued as a supplement with the book, at no extra charge, gives the same information, although covering a wider range, and the "curves" are straight lines. The condensed chart is in the book so that when one has the book with him away from home or laboratory he still has sufficient information for everyday work, while the supplement, 18 x 20 inches, is preferable for the most exacting demands of accuracy and wide frequency coverage.

From the tri-relationship chart (either one), the required inductance value is read, since frequency and capacity are known by the consultant. The size and insulation of wire, as well as the diameter of the tubing on which the coil is to be wound, are selected by the user, and by referring to turns charts for such wires the number of turns on a particular diameter for the desired inductance is ascertained.

There are thirty-eight charts, of which thirty-six cover the numbers of turns and inductive results for the various wire sizes used in commercial practice (Nos. 14 to 32), as well as the different types of covering (single silk, double silk, single cotton, double cotton and enamel) and diameters of ¾, ⅞, 1, 1⅛, 1¼, 1⅜, 1½, 1¾, 2, 2¼, 2½, 2¾ and 3 inches.

EACH turns chart for a given wire has a separate curve for each of the thirteen form diameters.

The two other charts are the tri-relationship one and a frequency-ratio chart, which gives the frequency ratio of tuning with any inductance, when using any condenser the maximum and minimum capacities of which are known.

The book contains all the necessary information to give the final word on coil construction to service men engaged in replacement work, home experimenters, short-wave enthusiasts, amateurs, engineers, teachers, students, etc.

There are ten pages of textual discussion by Mr. Shiepe, graduate of the Massachusetts Institute of Technology and of the Polytechnic Institute of Brooklyn, in which the considerations for accuracy in attaining inductive values are set forth. These include original methods.

The curves are for close-wound inductances, but the text includes information on correction factors for use of spaced winding, as well as for inclusion of the coils in shields. The book therefore covers the field fully and surpasses in its accuracy any and all mechanical aids to obtaining inductance values.

The publisher considers this the most useful and practical book so far published in the radio field, in that it dispenses with the great amount of computation otherwise necessary for obtaining inductance values, and disposes of the problem with speed that sacrifices no accuracy.

The book has a flexible colored cover, the page size is 9 x 12 inches and the legibility of all curves (black lines on white field) is excellent.

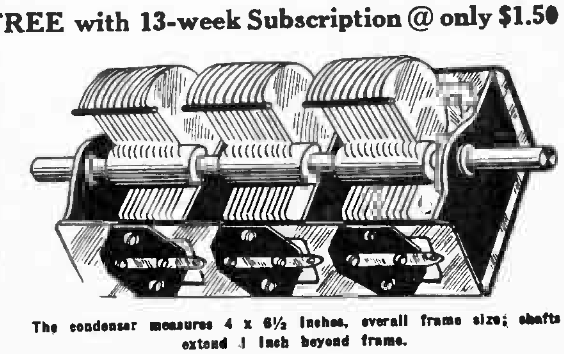
Send $4.00 for 34-week subscription for RADIO WORLD and order Cat. PIA sent free, with supplement, postpaid in United States and Canada.

RADIO WORLD
145 West 45th Street New York, N. Y.

An Extraordinary Bargain!

Three-Gang Condenser FREE with 13-week Subscription @ only $1.50

THE highest grade commercial gang condenser made, die-cast frame, brass plates, ⅝" diameter shaft extending at both ends. Condenser can be used therefore with either direction of dial rotation. Rigidity is of highest degree. Rotors can be shifted on shaft and locked tight for peaking at high-frequency end of band, thus dispensing with trimmers. Capacity, 0.0004 mfd. Full band coverage 1,500 to 540 kc (and more) with coils intended for 0.00035 to 0.00041 mfd. Premium sent express collect (shipping weight 5 lbs.) on receipt of $1.50 for 13 weeks subscription for Radio WORLD (13 issues).



The condenser measures 4 x 6½ inches, overall frame size; shafts extend 1 inch beyond frame.

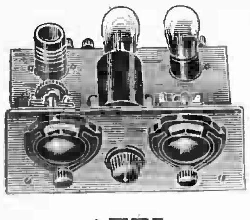
RADIO WORLD, 145 West 45th Street, New York, N. Y.

Introducing - - -

NEW 1934 DIAMOND of the AIR

A-C OPERATED SHORT-WAVE RECEIVERS

12,500-Mile Reception

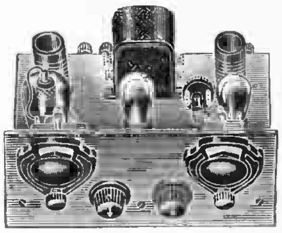


2-TUBE

Introducing the latest in short-wave receivers. The "Diamond of the Air" 2- and 3-tube battery receivers for many months have been acclaimed by owners to be the most remarkable short-wave receivers in their class. Now, for the first time, Reliable Radio Company introduces the 1934 A-C SHORT-WAVE "DIAMOND"—incorporating all the features of the battery-operated sets plus the convenience of a-c operation. The receivers have to be powered additionally and the power pack quotations will be found on this page.

IMPROVED RECEPTIVE QUALITIES

All 1934 features have been incorporated in the new "Diamond of the Air" a-c short-wave receiver and, besides, the popular battery-operated models have been improved in a new 1934 design. The lowest in price, yet these sets will log stations from all parts of the world regularly.



3-TUBE

The A-C "Diamond of the Air" Receivers

The a-c receivers have been developed for those who have the benefit of electric service. They use the latest type triple-grid tubes, resulting in more selective and sensitive reception. The 2-tube model employs a 57 tube, resistance coupled to a 56 type output tube. For those desiring to use this receiver on batteries, simply replace the 57 type tube with a 77 and the 56 tube with a 37, for heater excitation from a 6-volt storage battery and use B batteries for plates. Loudspeaker reception on all local and many distant stations.

The 3-tube a-c receiver uses a 58 as an r-f amplifier, followed by a 57 detector and a 56 as an output tube. This receiver can be used on batteries by using 77, 78 and 37 tubes as detailed above. Capable of logging stations from all parts of the world.

Employs the Highest-Grade Materials

A receiver is only as good as the parts used in its construction. Only the finest parts are included. **Hammarlund** condensers, representing the finest, are used. The metal panel eliminates body capacity.

DIAMOND OF THE AIR

Battery-Operated Short-Wave Receivers

The battery-operated receivers employ the 2-volt low-current tubes, saving considerable expense to those living in districts where no a-c is available.

The two-tube model uses two 30 tubes. Especially designed for headphone reception, although loudspeaker reception may be obtained at ordinary room volume.

The 3-tube two-volt model employs one 34 and two 30 tubes. It will receive short-wave stations from all parts of the globe on a loudspeaker.

Electric Models

Cat. No. 5025-D. Two-tube A-C kit, with blueprint. Shipping weight, 5 lbs. $8.45

Cat. No. 5026-D. Above, wired and tested. Shipping weight, 5 lbs..... 9.45

Cat. No. 5027-D. Complete set of tubes for above, either one 57 and one 56 for a-c operation or one 77 and one 37 for battery operation. Specify which. Shipping weight, 2 lbs.......... 1.45

Cat. No. 5028-D. Three-tube a-c kit, with blueprint. Shipping weight, 7 lbs. 11.45

Cat. No. 5029-D. Above, wired and tested. Shipping weight, 7 lbs..... 13.45

Cat. No. 5030-D. Complete set of tubes, either one 58, one 57 and one 56 for a-c operation or one 78, one 77 and one 37 for battery operation. Specify which 2.45

Two-Volt Battery Models

Cat. 5019-D. Two-tube kit, with blueprint, less accessories listed below. Shipping weight, 5 lbs.......... $7.75

Cat. No. 5020-D. Above, wired and tested, less accessories listed below. Shipping weight, 5 lbs.......... 8.75

Cat. No. 5021-D. Complete accessories including two 230 tubes, one set of standard headphones, two No. 6 dry cells, two standard 45-volt B batteries. Shipping weight, 22 lbs.......... 4.50

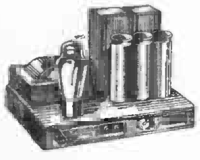
Cat. No. 5022-D. Three-tube kit, with blueprint, less accessories listed below. Shipping weight, 7 lbs.......... 9.95

Cat. No. 5023-D. Above, wired and tested, less accessories listed below. Shipping weight, 7 lbs.......... 10.95

Cat. No. 5024-D. Complete accessories, including two 30 tubes and one 34 tube, one set of standard headphones, two No. 6 dry cells, three standard 45-volt B batteries, one 6-inch magnetic speaker. Shipping weight, 32 lbs.......... 8.95

DIAMOND of the AIR SHORT-WAVE

POWER PACK



Supplies clear hum-free power regardless of circuit sensitivity. Especially designed for use with the "Diamond of the Air" Short-Wave receivers, but can be used on any short-wave battery-operated receiver for B supply.

Contains a brute-force filter, employing two heavy-duty 30-henry chokes, specially-designed power transformer, and three electrolytic condensers. These factors assure pure d.c.

Will deliver 180 volts. Supply your own taps. 135, 90 and 45 volts. Supplies 2½ volts at 10 amperes for filament drain. All taps terminate at binding posts on the side of the pack. Employs an 80 rectifier. Will stand up to 75 ma. drain for B current.

All parts are mounted on a sturdy metal base finished in silver.

Cat. DAPP. Price, including 80 tube $5.95

Shipping Weight, 20 Lbs.

Reliable

Four-Tube A-C Short-Wave Receiver with Built-In Speaker

Will tune in short-wave stations from all parts of the world with ease. Uses four plug-in coils to cover the entire short-wave band from 15 to 200 meters. The built-in power supply is entirely free from hum or disturbing line noises. Uses an ultra-sensitive dynamic speaker which aids in tuning in the weaker signals.

Cat. 4TK. Kit of Parts, less cabinet, less tubes **$11.50**

Cat. 4TW. Above, completely wired and tested.......... **$13.75**

Cat. 4TCB. Cabinet only...**$1.50** extra

Cat. 4TTU. Complete set of licensed tubes.......... **$2.50** extra

Reliable Radio Company

145 West 45th Street
NEW YORK CITY

POWERTONE SHORT WAVE WORLD RECEPTION A.C. D.C. RECEIVERS

For A-C and D-C Operation

Will work anywhere that 110 volt A-C or D-C is available. U. S. amateur reception is assured on loudspeaker by the use of a 43 power tube in the output.

With headphones the entire world is at your finger-tips. Chassis is completely encased in a beautiful crystal finished cabinet. Covers the short wave, band from 15-200 meters. Uses one 78, one 25Z5 and one 43 tube.

Price Kit.......... $8.95

Wired..... **$2.00** extra. Tubes...... **$3.25**

FREE

HANDY SERVICEMEN'S **MANUAL** WITH EACH PURCHASE OF A SHORT-WAVE RECEIVER

ALL SHIPMENTS MADE EXPRESS COLLECT UNLESS OTHERWISE DIRECTED BY PURCHASER